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APPLIED MECHANICS REVIEWS

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MECHANICAL TESTING OF SOLID MATERIALS

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MECHANICAL properties can be defined in a very general way as the relation between strain tensor, stress tensor, and time.

ELASTIC CONSTANTS

For many important engineering materials the stress-strain relation is independent of time and is linear for stresses inside the working range. The coefficients of the linear relation determine the elastic constants, such as Young's moduli, Poisson's ratios, and shear moduli. They can be determined from static tests at room temperature as follows:

Young's modulus is determined most frequently from a tension test of a long specimen (1).[1] It can be determined on small specimens of thin sheet from a compression test with lateral guides to prevent buckling (2) and for wire from twisting tests of helical springs (3). The compressive test has become the favorite static test for determining Young's moduli for nonmetals, including orthotropic materials such as wood (4) with widely different moduli in the three principal directions. Bending tests are often used to determine Young's modulus, particularly for brittle materials (5), wood (6), and structural plastics (7) in which it is easier to measure lateral deflection than axial strain.

The shear modulus may be determined conveniently from twisting tests of tubes (8) and from deflection measurements on helical springs (3). It can be obtained for orthotropic as well as isotropic plates by twisting a square specimen by transverse forces at the corners (9, 10).

Poisson's ratio for thin sheet metal is commonly obtained by measuring transverse and axial strain on tensile specimens cut from the sheet. On cylindrical specimens it is usually obtained by measuring the change in diameter as the specimen is subjected to axial load (11, 12, 13).

Compressibility can be determined either by the classical external pressure method (14, 15) or from internal pressure tests of thin-walled tubes with closed ends (16).

Dynamic methods rather than static methods must be used to determine the elastic constants of metals at elevated temperatures and of many plastics at room temperature, since these tend to creep under static load. Young's modulus has been determined from the resonance frequencies of bars vibrating axially (17), of rings bent in their plane (18), of cantilever beams (19) and bars supported at their nodal points and vibrating flexurally (20), and observations of beat frequency in a coupled pendulum (21). The shear modulus may be determined dynamically from the natural frequency of a bar vibrating in torsion (17) or of a torsion pendulum (22–24). Poisson's ratio may be determined from vibration tests of square plates (12). The accuracy of the elastic constants determined by these resonance methods depends, of course, on the completeness of the elastic theory connecting the frequency with the elastic properties, dimensions, and conditions of restraint of the specimen. The demands on the theory are of an entirely different nature in the case of the ultrasonic pulse technique (25–27). Pulses of longitudinal vibrations have been used to determine Young's modulus (28, 29) in small solid specimens as well as in long rods of metal heated to a high temperature at one end. Pulses of shear vibration have been used to determine the shear modulus (28, 29). The extension of dynamic methods to the determination of the elastic constants of anisotropic materials has been reviewed thoroughly by Hearmon (30).

DAMPING

The damping capacity (31–33) is usually defined as the fraction of the energy dissipated during a cycle of vibration. It may be measured by the logarithmic decrement in amplitude during free vibration (22, 23, 33–36), the half-width of the resonance curve (24, 37), the power required to maintain vibration at a given amplitude (20, 38), the "complex modulus" connecting a sinusoidal exciting force and the resultant motion during a vibration test (24, 39, 40), or the complex modulus describing the propagation and decay in amplitude of a pulse of ultrasonic vibration sent through the material (29, 41). It must be remembered that the damping capacities obtained by these different methods will agree with each other only if the damping is linear, i.e., proportional to velocity.

PLASTIC YIELDING

Most of the determinations of the stress-strain relation beyond the elastic range are still conducted in tension under conditions of negligible creep, but more and more compression tests are being made, due to the new techniques using lateral guides against buckling (2, 42–46). The stress-strain relations for states of biaxial stress including shear may be determined from tests of tubes under internal pressure, torque, and axial load acting singly and in combination (8, 47–51), from bulging tests of plates under lateral pressure (52), and tests of square plates under twisting loads (53). Interest in the yielding in individual crystals, in the properties of rare metals, and in the material properties for the

[1] Numbers in parentheses refer to the References at end of the paper.

transverse direction of structural members has led to the development of testing techniques for miniature specimens (54–56). There are still no tests under known three-dimensional states of stress, except those involving external pressure (14), in spite of the great importance of three-dimensional stresses for the transmission of force across small regions of contact, and at discontinuities such as notches and holes. Ball indentation tests with their complicated and unknown three-dimensional stress distribution are still widely used to compare the "hardness" of metals with each other. Microhardness tests of thin coatings and of brittle materials are being made increasingly with diamond indenters, frequently utilizing new and ingenious techniques (57–60).

The complications of measuring plastic yielding become much greater in the presence of creep which introduces time as an additional variable in the determination of strain. The literature on creep testing has already been reviewed by J. Marin (61) in a well-documented article of this series. Interest in the effects of time on the phenomena of yielding has led to the development of ingenious techniques for producing longitudinal plastic waves in a long rod (62, 63) and for observing the yielding under suddenly applied loads (64).

FRACTURE

Fracture in service occurs only rarely under the condition of uniform static tension specified in the standard tensile test. The effect of combined stress is important and it can be studied in cylindrical and tubular specimens under combinations of axial load, torque, internal pressure, or external pressure (65–71), and in spinning tests of rotors (72, 73). Fracture under less well-defined states of three-dimensional stress is obtained in notched-bar tensile tests (74). The effect of specific stress concentrations is obtained from "tear tests" of specimens with standard notches (75, 76). The permanent strain distribution after fracture near holes and notches can be measured with the new photogrid technique (77, 78), in many cases.

Fracture under repeated cyclic stressing (fatigue) has been ably discussed by R. E. Peterson (79) in a previous review of this series.

A great deal of attention has been given to improving the techniques of testing materials under transverse impact (80–85) to throw light on failures such as those of ship plates at low temperature, which seem to be associated with a low capacity of the material to absorb energy rather than to transmit stresses. The axial impact test has been developed to investigate strain-rate effects including the "critical speed" of straining specimens (86–90).

INSPECTION FOR DAMAGE

Dangerous residual stresses in materials can be detected sometimes by x-ray techniques (91–94) or by the crack pattern in a brittle lacquer coating around a hole drilled in the material (95). A lively, but so far unsuccessful search is under way for a reliable indicator of incipient fatigue failure (96, 97). Flaws can be detected (98, 99) by their effects on magnetic (100–102) and electrostatic fields (103), by radiography (104–106), with fluorescent penetrants (107), by ultrasonic probing (108–111), and with brittle lacquer coatings (112). Catalogues of typical failures in service (113–115) and the microscopic examination of fractures (116, 117) are becoming increasingly helpful in tracking down the cause of failures in service.

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Communications

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The review of Dr. Szablewski's article should read as follows:

The differential equation for fully developed turbulent flow in a pipe is integrated using Prandtl's mixing length relations. The integration starts at the wall and considers two regions, the laminar sublayer, a region where the order of magnitude of the laminar and turbulent friction is the same, and the entirely turbulent region. The solution for these two regimes is used as approximation for the remainder of the pipe flow. Appropriate values of the empirical coefficients give good agreement with experimental results of Nikuradse. H. P. Liepman, USA

Theoretical and Experimental Methods

(See also Revs. 1620, 1638, 1671, 1704, 1878, 1899)

1598. Collatz, L., Numerical treatment of differential equations [Numerische Behandlung von Differentialgleichungen] (in German), Berlin, Springer-Verlag, 1951, xiii + 458 pp. DM 48.

The book may be considered a notable extension of the subject matter contained in a number of texts on numerical analysis. Its first chapter treats the numerical solution of initial-value problems for ordinary differential equations, a topic contained in most of the conventional books. The remaining four chapters deal with subjects not normally found, namely, the solution of initial-value problems for partial differential equations, and of boundary-value problems for ordinary and partial differential equations. The last chapter presents some methods for dealing with integral and functional equations.

The list of methods presented is not claimed to be exhaustive but does contain almost all known ones, as well as some of the more obscure. For the integration of ordinary differential equations, the methods of Runge and Kutta, of Milne, and various difference methods are derived. The corresponding problems in partial differential equations are treated by finite-difference methods. The method of characteristics is shown only for first-order equations. For the treatment of boundary-value problems in one or more dimension, the methods of finite differences, relaxation, of successive approximations, and the method of Ritz share the main emphasis of the presentation. Solutions to integral and functional equations are shown by summation and by iteration. Formulas for estimation of the error are given whenever feasible. Numerous examples are worked out as illustrations to the methods developed.

The book fills, it is felt, an important need. It is the first one to present advanced numerical methods in an easily surveyable form. Its usefulness should be enhanced by the availability of automatic computers to carry out the methods described in it. It is questionable, however, whether it will realize its author's hope, namely, to convince its user of how little effort is required to obtain an idea of a solution by numerical methods.

R. Drenick, USA

1599. Bückner, H., Big calculating machines (in Italian), *Ric. sci.* **21,** 8, 1316–1363, Aug. 1951 = *Cons. Naz. Ricer.* no. 314, 50 pp., 1951.

Detailed description of the mechanical differential analyzer and a brief description of punched-card machines. Discussion of the logic of automatic digital machines concludes with a few remarks on the EMAC. William A. Mersman, USA

1600. Henderson, J. G., Mechanical harmonic analyser and some applications to servo systems, *Engineering* **173,** 4485, 4486, 52–53, 68–70; Jan. 1952.

A friction disk with horizontal axis is forced to rotate an amount $n\theta$ about a vertical line through its center, and also to rotate an amount $h(\theta)$ about its horizontal axis. The disk will not translate. In rotating, it causes translation of a resolver plate on which it rolls, and which cannot rotate. After one period of the curve to be analyzed has been traced, the resolver plate will have rectangular components proportional to the Fourier coefficients of the nth harmonic in the derivative curve $h(\theta)$. A simple calculation will then yield the Fourier coefficients for $h(\theta)$.

The analyzer is so constructed that n can be varied continuously. The position of the resolver plate always exhibits the integrals ${}_0\int^{\Omega}(dh/d\theta)\ [\{\sin, \cos\}\ n\theta]d\theta$. Use of these properties is made in an illustration showing how transient response can be determined from the frequency-response curve of a system.

R. E. Gaskell, USA

1601. Wilkes, M. V., Wheeler, D. J., and Gill, S., The preparation of programs for an electronic digital computer, Cambridge, Mass., Addison-Wesley Press, Inc., 1951, 167 pp. $5.

Part I of this three-part book has seven chapters which contain: (1) A brief discussion of the general principles of coding for electronic machines; (2) description of the machine and input

orders of EDSAC; (3) classification of subroutines into open or closed types, depending upon how they are incorporated into the main routine; (4) catalogue of the main types of subroutines available on EDSAC, according to the kind of operation effected; (5) description of common mistakes in preparing or combining programs; (6) description of EDSAC from a user's point of view; (7) examples on how subroutines are combined into a program. Part II contains the detailed specifications on the operations performed, parameters available, information required, etc., for the library of subroutines available to EDSAC users. Part III has some detailed examples of selected subroutines.

This book is not only an operating manual on EDSAC, but more important, it contains the embodiment of much original thinking on a well-integrated method of operating an electronic computer. The method depends on a flexible system of modifying numbers and orders as they are transferred from punched tape to the electronic memory of the machine. So much of this depends on machine construction that it will not be immediately applicable to the kind of parallel machines being built in the United States. Some sections, such as that on interpretive subroutines for working with double length or floating decimal-point numbers, have wide application. Because of the prime importance of input orders and the resulting notation, it takes some practice to learn this way of coding, even for one familiar with the flow diagram procedure of Von Neumann et al. Thus the book would be difficult to read for those whose interest in coding is casual; for those who expect to assemble and use subroutines, it is most valuable; for those who expect to design subroutines, it is essential.

The style is somewhat abbreviated, but the unusual format is governed by the nature of the material. The arrangement is useful, in that Part I contains almost all that would be of interest to most readers. C. C. Gotleib, Canada

1602. **Ekelof, S., Mathematical machines in Sweden** (in French), *Trans. Chalmers Univ. Technol.* no. 116, 26 pp., 1951.

1603. **Palazzi, A., Sampling of solid materials in pieces by the method of random samples** (in French), *Rev. Métall.* **49**, 1, 22-34, Jan. 1952.

Paper deals with sampling for determination of the percentage of a component in a solid material given in pieces of mean diam d. The necessary weight P of the whole sample is determined in order to obtain a precision σ_x in a number π out of 100 cases of sampling. After the dispersion of x in the material has been established experimentally, the necessary number N of samples and their weight P/N can be determined from σ_x and π. x is determined in a reduced part P_{red} of P after the material is ground to a reduced diam, d_{red}, obtained from d, P, and P_{red}. Various consequences of these relations are considered. Illustrative nomographs and examples are given. P. Kriezis, Greece

©1604. **Lohr, E., Vector and dyadic calculus for physicists and technicians [Vektor- und Dyadenrechnung für Physiker und Techniker] 2nd ed.,** Berlin, Walter de Gruyter & Co., 1950, xv + 488 pp. DM24.

Book is divided into three main parts: Arithmetic and algebra of vectors and dyads; calculus (differential and integral) of vectors and dyads; and physical applications. Author has adhered to the notation of J. W. Gibbs and G. Jaumann throughout the book.

In the first part, vectors, dyads, triads, etc., are treated from essentially an axiomatic point of view. The second part considers the calculus of these quantities, and the usual theorems (e.g., Stokes' and Gauss') are proved. The third part contains applications to mechanics, geometry, elasticity, hydrodynamics, electromagnetics, and quantum mechanics. A new section, not contained in the earlier edition, contains further physical applications. A. Devinatz, USA

©1605. **Dugas, R., History of mechanics [Histoire de la mécanique],** Neuchâtel, Switzerland, Griffon, 1950, 649 pp. $17.50.

Author confines himself, in the first part of the book, to the development of the principles of dynamics, and more or less incidentally, of statics. The last part is devoted to the development of the relativity theory and quantum and wave mechanics in their modern form. Mechanics of materials is outside the scope of the work; celestial mechanics and hydrodynamics are touched on. Applications and hence technology are left to one side.

Chronological order is used, the book being divided into five main sections: The first treats of origins and precursors up to the 16th century (for Dugas, classical mechanics begins with Stevinus); the second, of the formation of classical mechanics through the 17th century; the third, of the organization of mechanics in the 18th century, culminating with Lagrange; the fourth, of selected topics in post-Lagrangian classical mechanics and some interesting 19th century criticisms of Newtonian mechanics; and the fifth, of modern physical mechanics up to about 1930.

Within the chosen limits, the history is remarkably complete, at least up to Lagrange. This completeness avoids the impression that any of the laws of mechanics were discovered in a single flash of inspiration by some genius; as author says, "The fall of an apple was not sufficient to produce enlightenment upon universal gravitation." Book is particularly good on the work of medieval mechanicians such as Jordanus of Nemore, Jean Buridan, Oresme, Dominique Soto, and the "talented amateur," Leonardo, though here author admits a debt to the historical researches of Duhem.

Author uses, with few exceptions, quotations from the original papers, which is most desirable from the historical standpoint. Reviewer finds D'Alembert's statement of his famous principle obscure (though Dugas calls it "perfectly clear"); the first statement of it in modern terms seems to have been by Lagrange, though it is plainly implicit in Newton's second law.

The last section, which begins with the Michelson-Morley experiments and discusses the contributions of such men as Lorentz, Einstein, Bohr, Heisenberg, Dirac, de Broglie, and Schrodinger, assumes a sound knowledge of higher mathematics and classical mechanics. Dugas believes that it is not the task of the historian to produce either textbooks or popularizations.

In the preface, Louis de Broglie credits author with "a great patience, an informed erudition, an exquisite critical spirit," and considers book superior, as a history, to Mach's classic "Science of mechanics." Reviewer concurs, and regrets that there is no comparable history of engineering mechanics, the nearest approach, to his knowledge, being H. F. Girvin's rather brief "A historical appraisal of mechanics" [Scranton, Pa., International Textbook Co., 1948, 275 pp.] A. D. Topping, USA

1606. **Semenov, M. V., The rôle of Russian and Soviet scientists in the theory of regulation of powered machines** (in Russian), *Trudi Sem. teor. Mash. Mekh.* **6**, 23, 5-29, 1949.

Automatic regulation originated in 1763 with I. I. Polzunov who invented the float used in flush toilets. Then came Watt and Poncelet. The foundations of modern regulation were laid by I. A. Vishnegradskiĭ (1876) who created the method of small oscillations. Western scientists tried to disparage his work, charging that he neglected dry friction; the author refutes this

criticism. The development was resumed in 1934 (I. N. Voznesenskiĭ and his pupils). In 1938, A. V. Mikhaĭlov discovered the stability criterion unfairly credited to A. Leonard. The work of the Moscow seminar on topological mechanics is credited simply to "A. A. Andronov and his pupils"; their method is rated as "the most powerful," and dismissed in twenty-four lines. The author regrets that the students of automatic regulation in aircraft instrumentation did not follow Voznesenskii in reducing their criteria to design-office level. Nevertheless, the Russian results have greatly outdistanced those of all foreign countries. The author makes no mention of the names of Lyapunov, Krylov, and Bogolyubov. A. W. Wundheiler, USA

1607. Davidson, H. R., and Fuller, D. L., A simple analog computer for thermodynamic calculations, *J. Phys. Coll. Chem.* **55**, 2, 200–203, Feb. 1951.

Computer consists of direct-current circuits with potentiometers. It gives the equilibrium constant $K = \exp\{-(\Delta F^\circ/RT)\} = \exp\{-[a + b(t + 273)]/R(t + 273)\}$, depending on a, b, and t. (ΔF° is the standard free-energy change, T the absolute temperature.) F. A. Willers, Germany

1608. Artobolevskiĭ, I. I., Mechanism for the solution of quadratic equations of the form $a_1x^2 + a_2x + a_3 = 0$ (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **80**, 4, 549–551, Oct. 1951.

The two roots of the quadratic equation are obtained mechanically by use of a slide, a double crosshead, and a pivot. Compare with an earlier paper of author [AMR **5**, Rev. 3] in which an additional pivot is employed.

Michael Goldberg, USA

1609. Tasny-Tschiassny, L., and Doe, A. G., The solution of polynomial equations with the aid of the electrolytic tank, *Austral. J. Sci. Res.* (*A*) **4**, 3, 231–257, Sept. 1951.

The conducting-sheet analogy (or electrolytic tank) of Lucas (1888) for finding the complex roots of algebraic polynomials with real coefficients, and Bloch's suggestion (1948) for extending the method to the case of complex coefficients, are developed in this paper into a method of successive approximations having the possibility of attaining any arbitrary degree of accuracy.

The complex variable Z in the given polynomial is replaced by $Z = uZ' + Z_0$ where u(real) and Z_0(complex) are so chosen that Z' is obtained in the tank more accurately than is Z. By successive conducting-sheet solutions, successively better values of u and Z_0 are determined, yielding more accurate determinations of Z' (and, consequently, of Z). This process is repeated as many times as is necessary to reach the desired accuracy. The paper is concerned mainly with the details of setting up and operating the tank.

While the tank method represents a highly ingenious application of function theory "in the flesh" to the solution of polynomials, this reviewer feels that harmonic synthesis methods are superior both in accuracy and convenience.

Walter W. Soroka, USA

1610. Johnson, L. H., Nomography and empirical equations, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1952, ix + 150 pp. $3.75.

This book gives a clear account of procedures to use in graphical summarization of data. This includes setting up a nomograph with as many as four variables, with parallel or Z-scales. A variety of equations in four variables are treated, which should cover most cases that would arise in practice. Part II describes procedures for fitting curves by empirical equations. Three-constant equations include parabolic, hyperbolic, and exponential. Four-constant equations are polynomials and weighted sums of exponentials. In practice, many others are likely to be expected, but this book shows by examples how to approach the problems.

Gilbert W. King, USA

1611. Schroeder, R., Practical introduction to nomography [Praktische Einführung in die Nomographie] (in German), München, Carl Hanser Verlag, 1951, 186 pp., 122 figs., 46 tables. DM 16.

Purpose of book is to present subject in sufficiently elementary form to require a minimum of mathematical background. In chapters I and II, single and double-entry tables, absolute and relative errors, and the relative advantages of tables and graphical representations are discussed. Chapter III introduces double scales and contains practical advice on how to carry out required numerical work.

Chapter IV deals with network charts. Advantages that may often be derived from the use of nonlinear scales are pointed out, and also the possibility of representing relations between more than three variables by means of compound networks is described. The elementary level of the book may be illustrated by the fact that four pages of this chapter are devoted to an explanation of the concept of logarithms and their computational use, and an additional five pages describe the construction of logarithmic scales. This chapter also includes a discussion of (linear) interpolation. Chapter V explains the construction of slide rules. Both the common logarithmic slide rule (A and B scales) and special-purpose slide rules, including those having several slides, are described. Chapter VI is devoted to alignment charts. The advantages and limitations of these versus network charts are discussed. Unfortunately, this section is limited to a description of charts having straight and parallel scales. Charts representing relations between more than three variables, and combinations of network and alignment charts are discussed in chapter VII.

Numerous examples, mostly concerned with workshop problems, are scattered throughout the book. For many, the construction is described in great detail so that beginners can easily follow the procedure. A short bibliography, limited to German publications, is included which could be of help for those seeking a more advanced treatment of the subject. George Rudinger, USA

1612. Gaynor, F., The new military and naval dictionary, New York, Philosophical Library, 1951, viii + 295 pp. $6.

1613. Neĭshuler, L. Ya., Tables for the transformation of rectangular Cartesian coordinates into polar coordinates [Tablitsy perevoda pryamougol'níkh dekartovíkh koordinat v polyarníye] Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 291 pp.

The rectangular coordinates (x, y) correspond to the polar coordinates (s, α) if $s = (x^2+y^2)^{1/2}$, $\alpha = \tan^{-1}(y/x)$. This table is for x and y integers up to 10,000. It is generally supposed that $y \geq x$. If x is the greater, then instead of α, $90° - \alpha$ is found, the x now being regarded as y of the table.

The extreme left-hand column of each of the pages 7–290 gives values of y. The first range of values of y (pages 7 to the first column of page 12) is 1000–1090. Corresponding to these values are ranges of x: 0–10 (5), 10–20 (15), . . ., 400–420 (410), . . . 820–860 (840), . . ., 1070–1105 (1105). Under each of these ranges of x are columns giving values of s, α, Δ. The values of s and α given correspond exactly to the bracketed values 5, 15, . . ., 1105, which are almost invariably the means of values at the ends of the ranges; an exception is illustrated by 1105. The values of Δs and $\Delta\alpha$ given in the Δ column are for interpolating so as to get the values corresponding to the exact x in a given

problem. (In the latter part of the volume, the Δ tables sometimes run up to 22 entries.) The angle α is given to a tenth of a minute, and s to 5S or 6S, usually 1D. For such a pair of values as 4 and 3, one would turn to $y = 4000$, $x = 3000$. Similarly for any other y less than 1000.

Illustrative values are worked out on pages 4–6. This table is far more elaborate than anything previously published for this particular purpose.

Courtesy of Mathematical Reviews R. C. Archibald, USA

©1614. **Spenceley, G. W., Spenceley, R. M., and Epperson, E. R., Smithsonian logarithmic tables to base e and base 10,** Washington, D. C., Smithsonian Instn., 1952, xii + 402 pp.

©1615. **Petrovskiĭ, I. G., Lectures on partial differential equations [Lektsii ob uravneniyakh s chastnimi proizvodnimi]** Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 303 pp.

Present book is a concise and lucidly written introduction to the subject of partial differential equations. Important results are carefully stated in the form of theorems and bring out the relevant hypotheses in each case. The proofs are presented clearly and directly. Chapter I, entitled "Introduction. Classification of equations," deals with Cauchy's problem, S. Kowalewsky's existence theorem, characteristics, E. Holmgren's uniqueness proof for Cauchy's problem, canonical forms for second-order linear partial differential equations in one unknown function of two independent variables, and canonical forms for systems of linear first-order partial differential equations in two independent variables. Chapter II, entitled "Hyperbolic equations," is divided into two parts: (a) Cauchy's problem in the domain of nonanalytic functions, and (b) vibrations. Part (a) deals with the "correct posing" of Cauchy's problem, Cauchy's problem for the wave equation in one, two, and three space-dimensions and for hyperbolic systems in two independent variables, Lorentz transformations, mathematical foundations of special relativity. Part (b) deals with vibration problems, the so-called "mixed" problems for the wave equation, and especially Fourier's method (expansion in terms of particular solutions obtained by the method of separation of variables) for the vibrating-string equation. Two proofs of the needed eigenfunction expansions are given, the first is variational, and the second by means of integral equations. Chapter III, entitled "Elliptic equations," deals with Laplace's equation, potential theory, solution of Dirichlet's problem for a circle by Poisson's integral. The uniqueness of the solution of the Dirichlet problem is proved by an elementary method (not involving Green's theorem) due to I. I. Privalov [*Mat. sbornik* **32**, 464–469, 1925] and the existence of the solution by means of the Poincaré-Perron method of sub- and super-harmonic functions. The difference equation method for the approximate solution of the Dirichlet problem is also considered. Parabolic equations are discussed very briefly in chapter IV. An interesting feature of the book is the presence, at the end of each of the last three chapters, of a brief but informative survey of related known results.

Courtesy of Mathematical Reviews J. B. Diaz, USA

1616. **Kaarsemaker, L., and van Wijngaarden, A., Tables for use in rank correlation,** *Comput. Depart., Math. Centre, Amsterdam Rep.* **R 73**, 17 pp., 1952.

Tables are extensions of rank correlation probabilities given by M. G. Kendall on p. 141 of "Rank correlation methods," London, 1948. These probabilities are based upon the similarity of the relative ranks of corresponding terms of two numerical series. Tables are given for series of length 4 to 100. Method of computation is indicated. Thomas Caywood, USA

1617. **Basualdúa, J. J., and Bignoli, A. J., Solution of elastic schemes by directed iteration** (in Spanish), *Cienc. y Técn.* **117**, 593, 187–213, Nov. 1951.

Several methods for obtaining solutions of simultaneous equations by iteration are considered and compared in a specific case of structural analysis. The term "directed iteration" is used to describe a sequence of iteration which is based on the best possible guess as to relative values of the unknowns. Reviewer wishes to point out that, in a sense, all iterative methods of solving simultaneous equations can be considered as based on guesses of the values of the unknowns. Such guesses determine the sequence of operations. In the particular example used in this paper, the convergence obtained by assuming all but one of the unknowns as equal to zero in the first equation, and then successively correcting the unknowns (continuous iteration), is practically as fast as that obtained by "directed iteration." Authors point out that all save one of the forms of iteration considered differ only in the order followed. James P. Michalos, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Rev. 1608)

1618. **Rabinowicz, E., The nature of the static and kinetic coefficients of friction,** *J. appl. Phys.* **22**, 11, 1373–1379, Nov. 1951.

Author describes an experimental method for determining the transition between static and kinetic friction in those cases when the former exceeds the latter. Surfaces of various kinds are pressed against each other by a block of 1 kg placed on an inclined plane. The energy that is required to start the block moving for a given angle is measured. It is found that the static coefficient of friction persists for very small distances (order of 10^{-4} cm) and then gradually falls off to values corresponding to the kinetic coefficient. This behavior is discussed and shown to be consistent with the assumption that the friction force is needed to shear the metallic junction which, according to recent theories, occurs between the metal surfaces.

The action of boundary lubricants is explained by the fact that they can either diminish the metallic interaction directly or prevent its increase during the sliding process.

D. De Meulemeester, Belgium

1619. **Richter, L., Speed reducers and accelerations** (in German), *Elektrotech. Maschinenb.* **68**, 24, 580–583, Dec. 1951.

Rotational displacements of a body about an axis depend on applied torques, resisting torques, and the speed changer (transmission). Formulas are derived for that speed reduction yielding the greatest acceleration under constant applied and resisting torques. A formula is established for assigning to a given speed reduction a figure of merit which is connected with the acceleration achieved. Similar considerations are presented when the driving and resisting torques depend either on angular position or velocity or time, and when slip is present or absent. The first part of the theory is applied to the performance of a specific bus.

R. M. Rosenberg, USA

1620. **Makarov, S. M., Investigation of the characteristic equation of a linear system of two equations of first order with periodic coefficients** (in Russian), *Prikl. Mat. Mekh.* **15**, 3, 373–378, May-June, 1951.

Method of Lyapunov is applied to investigation of roots of characteristic equation of linear system:

$$dx_1/dt = \mu(p_{11}x_1 + p_{12}x_2),\ dx_2/dt = \mu(p_{21}x_1 + p_{22}x_2)$$

where p_{ik} is continuous, bounded periodic function of real period

$\omega = \omega(t)$; μ a parameter. The solution is sought in form: $x_{sr} = \delta_{sr} + \mu x_{sr}^{(1)} + \mu^2 x_{sr}^{(2)} + \ldots$ ($r, s = 1, 2$; $\delta_{sr} = 1$ if $s = r$, $\delta_{sr} = 0$ if $s \neq r$) where $x_{sr}^{(n)}$ are functions of t vanishing at $t = 0$. Author shows that with $\mu = -1$, functions $p_{ik} = p_{ik}(t)$ assume negative or zero values (not identically zero), then roots of characteristic equation will always be real.

Case of imaginary roots is studied using system $dx_1/dt = p_{12}x_2$; $dx_2/dt = -p_{21}x_1$, which is obtained from so-called complete system by a transformation. Investigation shows that if coefficients p_{12} and p_{21} are continuous, bounded, real, and periodic of real period $\omega = \omega(t)$, then they take positive or zero values (not identically zero).

Lyapunov system of equations is shown to be a special case of author's complete ones. S. Sergev, USA

1621. Kolchin, N. I., Applications of the formulas for a worm gear to special cases of meshing (in Russian), *Trudi Sem. teor. Mash. Mekh.* **5,** 19, 82–102, 1948.

This is the second part of the author's paper on skew worm gears [title source, **3,** 9, 18–51, 1947; AMR **5,** Rev. 990] applying its formulas to the case of an involute helicord worm meshing with a straight rack. He determines the contact lines (they are straight), the surfaces, and the angles of meshing. The same is done for a screw helicord worm. Author uses the same equations to determine the surfaces of a hob and a disk-shaped milling cutter for involute and screw helicoids. All equations are parametric in Cartesian coordinates. There are eight pages of numerical examples and graphs. A. W. Wundheiler, USA

1622. Sakharnikov, N. A., Solution of a case of the problem of the center and the focus (in Russian), *Prikl. Mat. Mekh.* **14,** 6, 651–658, Nov./Dec. 1950.

The author considers the system of equations

$$dx/dt = y + F(x, y), \quad dy/dt = -x - G(x, y),$$

where F and G are homogeneous polynomials of the third degree, and gives the necessary and sufficient conditions that $x = 0$, $y = 0$ represent a focus or a center. R. Bellman, USA

1623. Neĭmark, Yu. I., and Fufaev, N. A., On an error of V. Volterra in his derivation of the equations of motion of a nonholonomic system (in Russian), *Prikl. Mat. Mekh.* **15,** 5, 642–648, Sept./Oct. 1951.

Volterra's equations

$$d(\partial T/\partial p_s)/dt = \Sigma a^r{}_{sk}(\partial T/\partial p_r)p_k + T_s + P_s$$

[*Atti Accad. Sci. Torino Cl. Sci. Fis. Mat. Nat.* **33,** 451–475, 1898] for nonholonomic systems are correct, but their derivation is based on the relation $d\delta x_i - \delta dx_i = 0$ which, in general, does not hold for holonomic systems. [This error was made and noticed by many writers.] The major part of the paper deals with errors in a paper of V. V. Dobronravov [*Unchenie Zapiski Moskov. Gos. Univ. Mekh.* **122,** tom II, 77–182, 1948] who, from the same wrong relation, derived a wrong form of nonholonomic equations and a wrong generalization of the Hamilton-Jacobi theorem. These are disproved by means of examples. The authors seem to blame all this on Volterra. A. W. Wundheiler, USA

1624. Kucharski, W., On the visualization and expansion of the theory of the pendulum with an oscillating fulcrum (in German), *Ing.-Arch.* **19,** 6, 388–399, 1951.

Paper deals in its first part with the investigation of the response of the system to velocity changes (impacts) of the fulcrum in the absence of external forces. The effect of oscillations of the fulcrum is found to be a torque tending to turn the axis of the pendulum into the direction of oscillation. In the second part, use is made of this result, and the solution is set up as a sum of a basic (low-frequency) motion (due to the above-mentioned torque) and a (high-frequency) perturbation term. The linearized equation shows the perturbation motion to be beats with amplitudes proportional to the sine of the angle between pendulum axis and direction of oscillations. Solutions and their stability are discussed for several examples.

Solutions obtained by the method of this paper differ from results of earlier investigations on the same subject in so far as they are not restricted to quasi-equilibrium positions.

Hans L. Oestreicher, USA

1625. Riftin, L. P., Analytic design of computing cams with two degrees-of-freedom (in Russian), *Trudi Sem. teor. Mash. Mekh.* **8,** 32, 5–30, 1950.

One half of this paper deals with elementary considerations of two-dimensional cam design. The other half is devoted to the pressure angle, defined as the angle between the absolute and relative velocities of the tip of the follower. This pressure angle is expressed in terms of the position and velocity parameters for sliding or rotating plane cams with sliding or rocking followers (flat or edged), and for two-dimensional sliding or helical cams with sliding or rocking followers. A. W. Wundheiler, USA

1626. Kostitsín, V. T., Determination of minimum cam dimensions for straight-line followers (in Russian), *Trudi Sem. teor. Mash. Mekh.* **3,** 12, 23–63, 1947.

The connection between the minimum size of a cam and prevention of frictional self-locking is examined. Assuming the contact between the follower and the guides to occur at four vertices of a rectangle of width d and length l, the distance of its center from the center of the roller being y, the formula, $\cot \gamma_{cr} = f(2y + l \mp fd)/l$, is derived for the minimum γ_{cr} of the pressure angle γ (between the cam normal and follower axis) at which self-locking occurs. The sign depends on the direction of motion; f is the coefficient of friction. The critical angle is a minimum for the lowest position of the follower. Let γ_0 be smaller than this min γ_{cr} by a prescribed safety margin. Then $\gamma_{max} \leqq \gamma_0$ is a design condition limiting the size of cam. From the relation $\tan \gamma = v/\rho\omega$ (ρ is the distance between the center of cam and roller) an expression for γ is derived. The cases of constant speed, constant acceleration, and simple harmonic motion are studied. In all these cases γ_{max} proves to be a decreasing function of the minimum cam radius R, and the design condition is found to provide a lower limit for R in terms of several design constants. Author concentrates on the dependence of R on l, and determines min $(R + l)$ as the answer to the over-all dimensions problem. Numerical examples are generous. For the general cam, author offers pure and mixed graphical procedures, extended also to followers with an offset. These procedures claim more than one half of the paper and are given detailed presentation. For a continuation of this work by the same author, see *Izv. Akad. Nauk SSSR Otd. tehn. Nauk* **1948,** 1531–1537; AMR **2,** Rev. 973. A. W. Wundheiler, USA

1627. Tishin, M. M., The profiling of the gas distribution cams of aviation motors (in Russian), *Trudi Sem. teor. Mash. Mekh.* **1,** 217–239, 1947.

Four cam mechanisms with rectilinear or pivoted followers (flat-faced or roller-equipped) are discussed. The symmetric cam profile is composed of circular arcs AA', AB, BC, CC', $C'B'$, and $B'A'$. The arcs AA' and CC' are centered at the center O of the cam; AB and $B'A'$ are concave, BC and $C'B'$ are convex relative

to O. The initial and final accelerations of the follower are given, as well as the lift of the follower and the radius of the initial arc of the cam. Accelerations are expressed in terms of the position and design parameters of the mechanism. These expressions lead to design conditions in the form of equations which can be solved numerically for the angles of the arcs involved. Graphs and numerical examples are provided. A. W. Wundheiler, USA

1628. **Tolle, O., New construction of the line of application of the resultant inertia force of a mechanism member in plane motion** (in German), *Ing.-Arch.* **19,** 6, 355–356, 1951.

Author adds another graphical method to those published earlier by H. Alt [*ZAMM* **6,** 58–62, 1926], O. Tolle [*Ing.-Arch.* **1,** 377–384, 1930, and *ZVDI* **74,** p. 1453, 1930], and K. Federhofer [*ZVDI* **74,** p. 234, 1930]. The acceleration b_K of a point K and the acceleration b_S of the center of mass S of a mechanism member M in plane motion are prescribed. The intersection of the line of application with the line through K and S is denoted by A. Author derives an expression for the line segment a between A and S. To locate the line of application, a is found graphically by means of the acceleration diagram of M. Tolle [*ZVDI* **76,** 799–800, 1932] applied together with the center of interia T_K with respect to K. If M is considered as a physical pendulum with the axis of suspension through K and having S as center of gravity, then T_K is identical with the center of oscillation. The following final construction is presented: If T_K is placed on line KS, a line through T_K and the terminal (S) of vector b_S intersects a line drawn parallel to line KS through the terminal (K) of vector b_K. This intersection is designated by A'. The line through A' parallel to b_S then represents the line of application of the resultant inertia force. This simplified method permits the geometrical location of that line without plotting of a.

Josef Boehm, USA

1629. **Tolle, O., Mass reduction and dynamical turning effort for the connecting rod of a crank mechanism** (in German), *Ing.-Arch.* 19, 6, 357–364, 1951.

Equation is derived for closer approximation of the reduced mass M_{r_2} of the connecting rod. The kinetic energy E_2 of the rod is determined (a) by referring to its rotation about its instantaneous center of rotation, and (b) by referring to its reduced mass M_{r_2} which is assumed to be in the center K of the crank pin. The new equation for M_{r_2} is obtained by equalizing (a) and (b) for E_2 and by introducing two approximations. Author avoids the use of substitute masses as applied by M. Tolle ["Regelung der Kraftmaschinen," 3rd ed., pp. 107–119]. Equation for the dynamical turning effort T_2 of the rod is changed accordingly by using the new expressions for M_{r_2}. The force T_2 can be calculated with higher accuracy for all positions of the crank. Further, paper presents a simple graphical method (force polygon) to find T_2 when the resultant inertia force of the rod is determined by means of one of the known constructions (see preceding review). The corresponding terms of the new equations for M_{r_2} and T_2 are compared with those of M. Tolle. Two types of rods are investigated: (a) the prismatic rod with $s_1/l = 0.50$, and (b) the rod with $s_1/l = 0.35$. In both cases, s_1 is the distance between K and the center of gravity; l rod length. Diagrams of M_{r_2} curve and T_2 curve vs. crank angle are illustrated. Finally, author represents a construction for the velocity v of the center K of the crank pin. He combines properly the diagram of kinetic energy vs. reduced mass (weight) (Massenwuchtdiagramm) of the three moving members of the crank mechanism with another rectangular coordinate system x, y, where a parabola is plotted with $x = v$ and $y = v^2/2g = x^2/2g$. This method is based on the fact that the instantaneous velocity v is proportional to $(\text{tg}\varphi)^{1/2}$ where φ is the angle included by the line from the origin O of the original diagram to a point of the "reduced mass-kinetic energy" curve (Massenwuchtkurve) and the abscissa axis. The velocity v_1 at any point P_1 of this curve is found by intersecting the line OP_1 with the y-axis in A_1. The abscissa pertaining to A_1 represents the desired velocity v_1.

Josef Boehm, USA

1630. **Abramov, B. M., An approximate method for the investigation of the motion of mechanisms, taking account of frictional forces** (in Russian), *Trudí Sem. teor. Mash. Mekh.* **6,** 22, 5–27, 1949.

When exact consideration of friction is impractical, the common expedient is to assume that the normal reactions are the same as the smooth ones and apply the conventional laws of dry friction. The paper reviews this procedure for systems of one degree of freedom, and maps it out for a five-bar linkage as an example of two degrees of freedom. Lagrange equations are used after the generalized friction forces are determined. Some closer attention is given to the case of a two-bar three-hinge component of a linkage. No insights into the phenomena are given.

A. W. Wundheiler, USA

1631. **Ferraro-Bologna, G., On the property of a new mechanism for a piston-mover** (in Italian), *Monogr. Lab. Aero. Polit. Torino,* 15 pp. = *Atti Accad. Sci. Torino* **84,** 1949–1950.

A new device is proposed for substitution of oscillating disk when reciprocating translation must be transformed into parallel rotation. Author states trigonometrical relations between angles, displacements, and their kinematical derivatives. He follows with dynamical considerations about inertia forces, torque, moments, and reactions. Geometrical constructions and Euler's equations are applied.

Actual advantages over oscillating disk are claimed but not proved. Paper is kinematically and dynamically correct, under assumption that friction forces are neglected.

Reviewer recognizes originality but he believes that disregarded friction forces would play an important role in technical applications from the viewpoint of mechanical efficiency.

Jorge Carrizo Rueda, Argentina

Gyroscopics, Governors, Servos

(See also Revs. 1764, 1855)

1632. **Marre, E., The Kardan errors in course-indicating instruments** (in German), *ZVDI* **93,** 26, 836–842, Sept. 1951.

Author says that the errors in Kardan mechanisms are often neglected; they can only be fully considered for special technical problems. He distinguishes objective Kardan errors and so-called projection errors, gives a theoretical discussion of the latter, developes a new "absolute" coordinate system for angles, and describes a new model which is error-free.

O. Bottema, Holland

1633. **Gamble, E. H., and Hatten, B. W., Design and analysis of conservative dynamic load simulator,** *J. appl. Phys.* **22,** 10, 1250–1257, Oct. 1951.

Authors present design for a dynamic load simulator in which the required dynamic load is actually applied to the test item. Dynamic load is computed electrically and applied through a hydraulic servomechanism. Use of induction motor to control hydraulic loading motor makes possible transfer of mechanical power fed into load into electrical power, which is returned to lines by induction motor acting as generator. Thus, necessity of dissipating load power as heat is avoided.

It is assumed that the dynamic load may be written as a second-order expression in deflection of the test item, plus a possible Coulomb friction term. Analysis is carried out neglecting Coulomb friction. Two applications discussed are used as test stand for testing autopilots, and aircraft control-load simulator for design and test of control systems. However, since control loads depend on airplane motions as well as control motions, it seems to this reviewer that dynamic loads on control surface cannot be simulated by an expression involving control motions only. It therefore seems that the electronic computer should also obtain the airplane motions caused by control motions, and these airplane motions may then be used in more complete expression for control load. Albert A. Sachy, USA

Vibrations, Balancing

(See also Revs. 1600, 1624, 1782, 1851, 1922)

1634. **Gorelik, G. S., Vibrations and waves. Introduction to acoustics, radiophysics and optics [Kolebaniya i volní. Vvedenie v akustiku, radiofiziku i optiku]** Moscow-Leningrad, Gosud. Izd. Tekhn.-Teor. Lit., 1950, 551 pp.

This text for physics students presents oscillatory and wave phenomena encountered in mechanics, optics, acoustics, and electricity from a unified point of view. The chapter headings are: Oscillations, superposition of oscillations, linear oscillatory systems, nonlinear oscillatory systems, waves, elastic waves, electromagnetic waves, complicated wave generators, diffraction, statistical phenomena, spectral analysis. The material presented is not developed further than up to the intermediate level. The chapter on elastic waves, for example, does not contain a treatment of Rayleigh's surface waves, and both damping and resonance are mentioned only casually. George Herrmann, USA

1635. **Söchting, F., Calculation of mechanical vibrations [Berechnung mechanischer Schwingungen]** (in German), Wien, Springer-Verlag, 1951, x + 325 pp., 140 figs. $7.80.

Book begins with exposition of fundamentals of simple vibrating systems. Brief treatment of nonlinear oscillations is included. Unusually extensive analysis is made of systems with different types of coupling.

Derivation of general linear equations of motion for elastic body is followed by consideration of vibrations of strings, rings, beams, membranes, and plates. Approximate methods, including those of Rayleigh, Ritz, Galerkin, and Grammel, are discussed and applied to specific problems such as vibrations of rotating beams and disks.

Final section of book is devoted to actual machines, emphasis being placed on vibrations of crankshaft of reciprocating engine and whirling of shafts. Book is characterized by number of references and abundance of solutions to practical problems. Robert P. Felgar, Jr., USA

1636. **Roberson, R. E., Vibrations of a clamped circular plate carrying concentrated mass,** *J. appl. Mech.* **18,** 4, 349–352, Dec. 1951.

Author determines the first four natural frequencies as functions of the mass ratio of a round circular plate clamped at its edges with a concentrated mass at its center. The plate is excited by a motion of the framing, assumed rigid, to which it is clamped. The motions of two subsystems with one degree of freedom are compared; one being driven by the framing, and the other by the concentrated mass on the plate. The plate subsystem has a response in excess of the response of the framing-mounted subsystem if the framing is suddenly put in motion. The subsystem resonance curves are depressed in height by an increase of the mass ratio except in the neighborhood of their peaks. The peak locations depend on the mass ratio.

From author's summary by Robert E. Heninger, USA

1637. **de Schwarz, Maria J., Determination of frequencies and nodal lines of an oscillating elliptic membrane with fixed contour** (in Italian), *Accad. Sci. fis. mat. Napoli* (3) **3,** 2, 1950 = *Cons. naz. Ricer.* no. 302, 15 pp., 2 tables, 1951.

If ρ, θ are polar coordinates, I_k Bessel functions of order k (positive integer), and λ certain eigenvalues, then the functions $I_k(\lambda\rho)\cos k\theta$, $I_k(\lambda\rho)\sin k\theta$ are known to be eigenfunctions for the free vibrations of a circular membrane with amplitude vanishing at boundary. In the case of an elliptic membrane, author approximates eigenfunctions with same functions, only modifying λ from conditions that amplitude shall vanish in certain prescribed points of elliptic boundary. No considerations of convergence occur in paper. Same problem is also attacked using asymptotic developments of certain Mathieu functions. Numerical calculations for an ellipse of axis ratio 1:2, using $k = 0 - 6$, show good agreement between approximate and exact methods, having regard both to eigenvalues and nodal lines, corresponding to 18 lowest frequencies of membrane.

Folke K. G. Odqvist, Sweden

1638. **Odqvist, F. K. G., An expansion of frequency determinants with application to the normal frequencies of a spring-mounted rigid body (resilient foundation),** *Quart. appl. Math.* 9, 4, 441–448, Jan. 1952.

Author is concerned with approximate expressions for the natural frequencies of oscillations of a system having n degrees of freedom. If all coupling terms are multiplied by a parameter λ, formal MacLaurin expansions are obtainable for each natural frequency. Since convergence is limited to sufficiently small λ, restrictions on the intensity of coupling terms as compared to diagonal terms are implied. Author shows on example of a spring-mounted foundation ($n = 6$) that, if some diagonal terms are included under λ because they are of the same small order of magnitude as coupling terms, similar expansions will hold, provided certain additional conditions of coupling are met.

Value of paper would be enhanced by inclusion of convergence criteria and numerical discussion of the approximations obtained. B. M. Fraeys de Veubeke, Belgium

1639. **Eringen, A. C., On the nonlinear vibration of elastic bars,** *Quart. appl. Math.* **9,** 4, 361–369, Jan. 1952.

Classical theory of transversal flexural vibration of beams is extended, taking account of the rotational motion of a beam element under action of moment, shearing, and axial forces, and the extension of the element as caused by the axial force. The three equations of motion of the element are all nonlinear in the components of the displacement and the angular deflection θ. As dependent variables, author introduces θ and the extension ϵ of the median line, and as independent variables, $y = x/L$ and $s = \lambda\tau$, where x is the coordinate in direction of the equilibrium position of the axis of the beam, and L its length. Further $\tau = (E/\rho L^2)^{1/2} \cdot t$ and $\lambda^2 = J/\rho A L^2$, where E is Young's modulus, t time, ρ the mass per unit volume, A the cross-sectional area of the beam, and J its mass-moment inertia per unit length. The system of two nonlinear partial differential equations for θ and ϵ does not reduce to a single equation in the case of $\epsilon = 0$ but to a system of two different equations for θ. When ϵ is a higher-order quantity than θ, however, the system leads to the classical theory as a limiting case. As a special case, author treats a simply supported beam with immovable ends, and expands the solution in power

series with respect to λ, where θ contains only odd and ϵ only even powers of λ. The coefficients of the series have to fulfill certain nonlinear partial differential equations, forming a recurrent system of rapidly increasing complexity. As initial condition, author assumes a beam at rest with a cosine distribution of θ. Retaining terms of the order λ^3 yields a solution with elliptic functions and, going one step further, i.e., retaining terms of the order λ^5, leads to more complex expressions containing Jacobian theta, eta, and zeta functions. To obtain the vibration produced by an arbitrary initial deflection, the recurrent system must be re-solved, since the equations are nonlinear. Following a similar method as G. F. Carrier's [title source, **3**, 2, 157–165, 1945] for the nonlinear vibrations of strings, a nonlinear integral equation is obtained, which may be solved by successive approximations. Numerical results show the period and axial stress as a function of initial deflection.

Folke K. G. Odqvist, Sweden

1640. **Schaffner, J. S., Almost sinusoidal oscillations in nonlinear systems. Part 1,** *Univ. Ill. Engng. Exp. Sta. Bull. Ser.* 395, 64 pp., 1951.

An elaboration of the "equivalent linearization" method of Krylov and Bogolyubov for the analysis of quasilinear systems is presented. Although the method given is general, it is presented in the language of electric circuit theory. Procedures useful in obtaining higher approximations are developed and questions of equilibrium and stability are discussed.

Louis A. Pipes, USA

1641. **Harrison, M., Syke, A. O., and Martin, M., Wave effects in isolation mounts,** *J. acoust. Soc. Amer.* **24**, 1, 62–71, Jan. 1952.

See AMR **4**, Rev. 4386.

1642. **Koiter, W. T., On Grammel's linearisation of the equations for torsional vibrations of crankshafts,** *Proc. k. Ned. Akad. Wet.* (*B*), **54**, 5, 464–467, Nov./Dec. 1951.

Author first writes down the complete equation for torsional vibrations of a crankshaft in which the effective moment of inertia at any crank is variable due to the reciprocating parts and a function of angular position of the crank. This equation contains the square of the crank velocity and is, hence, nonlinear. From this equation Grammel's linearized equation is obtained; then it is shown how two additional linear terms should really have been included in Grammel's equation, since neither of these terms is negligible in itself.

In second part of the paper, author shows that these two additional terms taken together are negligible, and that Grammel's linearized equation therefore is valid to a first approximation.

N. O. Myklestad, USA

1643. **Oesterreicher, H. L., Field and impedance of an oscillating sphere in a viscoelastic medium with an application to biophysics,** *J. acoust. Soc. Amer.* **23**, 6, 707–714, Nov. 1951.

Although paper does not definitely say so, the problem treated seems to be that of the effects on human beings of the high-frequency oscillations produced by gas turbines and other new types of aircraft power plants. Human muscle is treated as an elastic-viscous medium or Voigt body, and the equations of motion are expressed in compact notation. Wave propagation, including compression and shear waves, is determined by four real constants—shear elasticity, compressibility, shear viscosity, and dilatational viscosity. Approximate values of the first three constants are given for human tissue, but no value has been obtained as yet for the last which is of no appreciable influence up to 20,000 cps. A comparison is given of calculated and measured values of reactance of human tissue at various frequencies up to 20,000 cps. Author's treatment of the problem and his very lucid side remarks about the viscoelastic equations will interest many who are stress analysts but not biophysicists.

W. C. Johnson, Jr., USA

1644. **Moreland, W. J., Landing gear vibration,** *Wright Air Develop. Center, AF tech. Rep.* 6590, 70 pp., Oct. 1951.

A simplified linearized analytical investigation is made of the shimmy phenomenon in a swiveling aircraft landing gear having a positive trail and, for the most part, an inelastic tire without side slip or distortion. The analysis considers the lateral elasticity of the gear with respect to the air frame and the influence of the finite mass and elasticity of the air frame. Generalized equations and a graphical procedure are developed for obtaining the damping required to prevent shimmy, and the necessary structural modifications to control shimmy are explained. Also a brief, somewhat insufficiently detailed consideration is made of the influence of tire elasticity.

Robert F. Smiley, USA

1645. **Nardini, R., On the equation of motion of an elastic beam with heredity** (in Italian), *Atti Semin. Mat. Fis. Univ. Modena* **4**, 68–87, 1949–1950.

Author extends work of Volterra and Graffi on hereditary systems. He considers a hereditary function $\Phi(t, \tau)$ for a beam, of more general type than the customary $\Phi(t - \tau)$, such as might be obtained in systems with time-variable coefficients; establishes uniqueness of continuous solution for pin-ended case; and discusses questions of convergence of solution. Paper is likely to be of greatest interest to the mathematical reader.

Robert E. Roberson, USA

Wave Motion, Impact

(See also Revs. 1634, 1643)

1646. **Malyuzhinets, G. D., Remark concerning the radiation principle** (in Russian), *Zh. tekh. Fiz.* **21**, 8, 940–942, Aug. 1951.

Author considers a case in wave propagation in which it is possible to have a negative phase velocity and, at the same time, a positive group velocity. The one-dimensional case only is treated, and an analogy is made with certain types of electrical filters.

R. T. Beyer, USA

1647. **Goodier, J. N., and Bishop, R. E. D., A note on critical reflections of elastic waves at free surfaces,** *J. appl. Phys.* **23**, 1, 124–126, Jan. 1952.

A *P* (plane irrotational) wave in a semi-infinite elastic solid is evanescent for certain angles of incidence on the free surface ("grazing" incidence); so also is an *SV* (plane equivoluminal) wave. Applying simple limit processes to plane wave solutions of the wave equation, authors show wave motions to be possible in these critical circumstances. An ordinary *P*-wave traveling parallel to the free surface gives rise to a "*Py*"-wave (amplitude proportional to y) moving in the same direction and a reflected *SV* wave of ordinary kind; similar results derived for incident equivoluminal wave. Note expression (8) for ψ should be multiplied by 2.

I. N. Sneddon, England

1648. **Dorrestein, R., General linearized theory of the effect of surface films on water ripples,** *Proc. k. Ned. Akad. Wet.* (*B*) **54**, 3, 4; 260–272, 350–356; 1951.

Author generalizes the discussion in Lamb's "Hydrodynamics" [6th ed., Cambridge Univ. Press, 1932, §349] to give a linearized theory of gravity waves which includes viscosity, surface vis-

cosity, and surface tension. The treatment of surface tension allows for compressibility of the surface film (i.e., a sort of two-dimensional gas law) and hysteresis. The method follows closely that given by Lamb, where only viscosity and constant surface tension are considered. Some relevant tables, pertaining chiefly to water, are included. J. V. Wehausen, USA

1649. **Sekerzh-Zen'kovich, Ya. I., Composite standing waves of finite amplitude on the surface of a heavy liquid of infinite depth** (in Russian), *Izv. Akad. Nauk SSSR Ser. Geofiz.* no. **5**, 68–83, 1951.

In earlier papers [*Doklady Akad. Nauk SSSR (N.S.)* **58**, 551–553 (1947); *Izv. Akad. Nauk, SSSR Ser. Geograf. Geofiz.* **15**, 57–73, 1951; see AMR **5**, Rev. 37] author has treated gravity waves of finite amplitude by using Lagrangian coordinates and expanding in a power series in a parameter. In the present paper he expands in a double series in two parameters in such a way that the linear terms give the sum of two sinusoidal (i.e., linearized) waves. Computation of the coefficients is given through the third power of the parameters. The form of the free surface is then given explicitly, retaining terms of the second order. Perhaps the most striking feature of the solution is the presence of "difference" and "summation" waves representing an interaction between the linearized waves. As in the earlier papers, there are no fixed nodes and free surface is never completely flat.
J. V. Wehausen, USA

Elasticity Theory

(See also Revs. 1645, 1666)

1650. **Feodosiev, V. I., Selected problems and questions in strength of materials [Izbrannîye zadachi i voprosî po soprotivleniyu materialov]**, Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 244 pp., 277 figs.

This valuable collection of nonconventional exercises is not for beginners but for ambitious advanced students, for experienced stress analysts, and for research workers in applied elasticity. The problems range from such subjects as tension, compression, and bending to stability of equilibrium and of motion, from the state of combined stress and theories of strength to questions concerning analysis of shells. As an example, we mention here problem no. 122 (pp. 53–55, 211) which gives an instructive illustration of Timoshenko, "Plates and shells," 1940, p. 386, lines below fig. 154. (This problem is, by the way, referred to by E. F. Zenova and V. V. Novozhilov in a paper on "Symmetric deformation of toroidal shells," *Prikl. Mat. Mekh.* **15**, 5, 521–530, 1951.) Not less than 75% of the book is devoted to the solutions of problems. It is of considerable educational value for the computing engineer. I. Malkin, USA

1651. **Gray, C. A. M., Polynomial approximations in plane elastic problems,** *Quart. J. Mech. appl. Math.* **4**, part 4, 444–448, Dec. 1951.

Muskhelishvili [*Math. Ann.* **107**, 282–312, 1932, and *ZAMM* **13**, 264–282, 1933] reduced the solution of the plane elastic problem for simply connected areas to the determination of two complex potential functions, given by two integral equations. The method requires the mapping of the loaded area conformally on a unit circle; solutions were presented for cases where the mapping function is rational.

The usefulness of the method is extended here to cases where the Taylor expansion of the mapping function is known. Series approximations to the complex potential functions are obtained by substituting a sufficiently large number of terms of the Taylor expansion of the mapping function into the integral equations (presented in a slightly modified form by the present author). Coefficients of the approximate series solutions are obtained by solving sets of simultaneous linear equations. Example treated is square loaded by two equal diagonal forces; results are checked against stresses determined photoelastically by Frocht.

The method is straightforward and suitable for solving many practical problems, the only disadvantages being the usual computational work involved in the solution of a large number of simultaneous linear equations, and the fact that no procedure is given for estimating the errors caused by the approximations.
G. Sved, Australia

1652. **Sobrero, L., Elastic stresses in a plane system with a reinforced opening,** *David W. Taylor Mod. Basin Transl.* 103, 33 pp., Sept. 1951.

Translated from *Reale Accad. Italia, Memorie Cl. Sci. Fis. Mat. Nat.* **10**, 4, 1939.

1653. **Sen Gupta, A. M., Bending of cylindrically aeolotropic circular plate with eccentric load,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-17, 4 pp. = *J. appl. Mech.* **19**, 1, 9–12, Mar. 1952.

Solution for bending of a thin circular isotropic plate, submitted to eccentric load, was given by Michell (1902). Equations for bending of a thin circular aeolotropic plate were deduced in a general manner by Carrier. It must be pointed out that these equations (referred to a problem of plane stress) involve three constants (against the two constants of isotropic plate). Author now applies Carrier's equations to solve the problem of bending of an aeolotropic circular plate with eccentric load. General solution is given in series form, but final formula for deflection in the center is very simple. Giulio Supino, Italy

1654. **Gassmann, F., On the plasticity of porous media** (in German), *Vierteljahrsschr. naturforsch. Ges. Zürich* **96**, 1–23, 1951.

"There are certain not strictly elastic systems which behave as perfectly elastic ones, provided the stress system makes only slight fluctuations around certain mean values. . . . Such stress fluctuations take place, for example, if elastic waves run through the system. It is indeed a known fact that elastic waves, both longitudinal and shear waves, are propagated through systems which are far from ideally elastic, such as sand, gravel, or clay, causing energy dissipations and permanent changes in the system which are negligible, just as if the propagation had taken place through an ideally elastic medium." The author calls this phenomenon "differential elasticity." He assumes for it the usual linear stress-strain relations but with "constants" possibly dependent on the state of deformation in which the system is at the start of the fluctuations. Assuming furthermore the solid frame of the porous material to be isotropic, author computes the apparent elastic constants and the wave velocities of the porous system in terms of the constants of the solid frame, of the pore-filling fluid, and the porosity of the system. Generalization of the formulas to the case when the frame consists of unisotropic material is outlined. The possible influence of capillarity is discussed.
P. Neményi, USA

1655. **Horvay, G., Stresses in perforated sheets due to nonuniform heating,** *Gen. Elec. KAPL* 566, 39 pp., Aug. 1951.

Author deduces thermal stresses in a perforated plate from those which he determined for a solid disk in a previous paper [AMR **5**, Rev. 50]. "Effective" elastic moduli and thermal coefficient are assumed for the purpose. The interest apparently

is in a plate with uniformly distributed hexagonal holes which author considers to be a limiting case of a plate with circular holes. The plate is an idealization of a tube sheet in a heat exhanger. Some consideration is given to reinforcing rims around the holes. Numerical results are given in the form of a series of curves. Elastic and thermal coefficients are assumed to be independent of temperature.

Reviewer notes that author does not consider the multiple connectivity aspect of the perforated plate when he attempts to approximate stresses from those in a solid plate. Thermal shock is again considered in this paper. Remarks about such a use of the expression are in the previously mentioned review.

W. H. Hoppmann, II, USA

1656. **Melan, E., Temperature distributions without thermal stresses** (in German), *Öst. Ing.-Arch.* **6**, 1, 1–3, 1951.

A more complete exposition of the subject matter of this paper was given by M. A. Biot, "A general property of two-dimensional thermal stress distribution," *Phil. Mag.* **19**, 540–549, 1935.

Max L. Williams, Jr., USA

1657. **Nabarro, F. R. N., The synthesis of elastic dislocation fields,** *Phil. Mag.* (7), **42**, 334, 1224–1231, Nov. 1951.

Starting from a set of formulas for the displacement components associated with a closed dislocation line as given by J. M. Burgers (1939) on the basis of Volterra's theory, author derives the expressions corresponding to an infinitesimal loop of dislocation lying in the x, z-plane near the origin, with dislocation vector **b** parallel to z-axis. The expressions are rewritten in a notation given by Love, which relates them to the displacements produced by constant forces acting at the origin. It is possible to pass to the displacements produced by time-dependent forces, and, from these, expressions are derived referring to the sudden creation of a dislocation loop. The latter in their turn are applied to obtain the field of a dislocation moving arbitrarily in its glide plane with subsonic speed. As an example, the rigid motion of a screw dislocation is considered (screw axis parallel to z-axis; point of intersection with x, y-plane: $\xi(\tau)$, 0). The disturbance spreads with the speed c of a shear wave, and is given by

$$u_z = -\frac{by}{2\pi}\int_{-\infty}^{\tau_0}\frac{\xi'(\tau)\cdot c\cdot(t-\tau)}{\rho^2[c^2(t-\tau)^2-\rho^2]^{1/2}}\,d\tau$$

where $\rho^2 = (x-\xi)^2 + y^2$; while τ_0 is given by $[x-\xi(\tau_0)]^2 + y^2 = c^2(t-\tau_0)^2$.

J. M. Burgers, Holland

Experimental Stress Analysis

1658. **Macek, O., Instruments for measuring internal stresses in transparent bodies** (in German), *ATM* no. 191, T133–134, Dec. 1951.

The normal photoelastic bench, as used with the stress analysis of plastic models, is not sufficiently accurate and sensitive for the determination of residual stresses in optical glass components. For practical purposes, the arrangement according to M. H. L. Tardy is recommended. The polarizer and analyzer are Glan-Thompson prisms, and the light source is a small incandescent lamp with a minochromatic filter. The test object is placed before a concave mirror to double the phase shift. The polarizer and analyzer with their $^1/_4$-wave plates can be rotated simultaneously. To determine the retardation at a certain point, the axis of the principal stresses are established by rotating the polarizer and analyzer until complete darkness, then the $^1/_4$-wave plates are arranged to provide circular polarized light and finally, after blocking the polarizer and the $^1/_4$-wave plates, the analyzer is rotated until re-establishment of complete darkness. The rotation angle of the polarizer is a measure for the retardation. It is claimed that a retardation of 4.10^{-7} can be determined with a plate thickness of 1 cm.

R. G. Boiten, Holland

1659. **Vedam, K., and Ramachandran, G. N., Photoelastic constants of sodium chlorate from ultrasonic diffraction,** *Proc. Ind. Acad. Sci.* (*A*) **34**, 4, 240–244, Oct. 1951.

Details are given of the theory and technique of measuring photoelastic constants in optically active cubic crystals from ultrasonic diffraction of light. The results thus obtained, in conjunction with the measurements of relative path retardation produced by stressing the crystal, enable one to obtain all the four constants independently.

From authors' summary

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1642, 1696, 1697, 1705, 1714)

1660. **Roisin, V., Sariban, A., and Zaczek, S., Analysis of statically indeterminate beams** (in French), *Ossature métall.* **16**, 9, 11; 428–442, 541–554; Sept., Nov. 1951.

Paper gives methods and provides tabulated formulas for the rapid resolution of numerous problems of continuous beams with from three to ten supports and with a wide variety of loadings.

W. S. Hemp, England

1661. **Säger, W., The twisted rectangular rod in which the end sections are prevented from warping** (in German), *Bauingenieur* **26**, 10, 11; 309–312, 330–333; Oct., Nov. 1951.

The problem has been studied by Timoshenko [*Proc. Lond. math. Soc.* **20**, p. 389, 1921] for the case of a very narrow rectangle, the form for the stress being $\sigma_z = AE\theta xye^{-Az}$ (z long axis) and the constant A being determined by the principle of minimum strain energy. Author intends to solve the case of any given rectangular section, taking into account that such sections are usual in reinforced concrete beams, in which the monolithic junction with the rest of the structure prevents warping; he tries to establish how far it is permissible to use Saint Venant's solution to find the twist reinforcement.

Given a homogeneous and isotropic material and the beam loaded with a constant twisting moment, author gets the solution by superposing: (1) State according to Saint Venant, i.e., free warping; (2) the stresses originated by a warping of end sections, determined by taking $-w = \theta \cdot \varphi(x, y) \cdot h(z)$, $\varphi(x, y)$ being a known function and $h(z)$ a function to be determined by using the elementary theory of bending.

The recorded perturbation is of local character, as the bending stresses disappear at most at a distance of $1.5d$ (d height) from the end section; for $L = 3d$, author gets the pure state of Saint Venant and, for normal beam proportions, the perturbation in the stresses is unimportant. In conclusion, the author recommends, for some cases, allowing a small excess at the end for the compression stress of the concrete, while ample reinforcement is to be provided at the side submitted to tension.

Article permits consideration of a rationally founded reinforcement at the built-in ends in some practical cases.

Arturo M. Guzmán, Argentina

1662. **Ōkubo, H., The torsion and stretching of spiral rods. I,** *Quart. appl. Math.* **9**, 3, 263–272, Oct. 1951.

An analysis is presented to determine the torsional deformation and stretching of spiral rods. The equations of equilibrium are

expressed in terms of displacements. They are developed into forms which are independent of the position of the section, and, therefore, they are independent of one coordinate. Author achieves this by translation and rotation of a system of coordinate axes of a section which is perpendicular to the axis of the helix. By fixing this system of axes to the section, it is translated and rotated about the axis of the helix together with the section along the spiral rod. In this manner, the stress distribution in the section in relation to the coordinate axes is constant for all sections. Differential equations of displacements are integrated for the special case of a small helix angle. Resulting expressions for displacements and stresses contain three arbitrary plane harmonic functions which can be determined when the shape of the section is known. As an application of the general solution, author considers a spiral rod of elliptical cross section and evaluates a numerical example. He arrives at the result that, while shape of cross section of a straight rod is not deformed by twist, the cross section of a spiral elliptic rod changes. The ellipse becomes flatter or rounder depending upon the axial elongation or contraction which takes place in a spiral rod when it is twisted. In solving the same numerical problem for stretching, author finds that the spiral rod is subjected to twist when it is pulled axially. Maximum and minimum normal stresses occur at the ends of the minor and major axes of the ellipse. The maximum shearing stress is at both ends of the minor axis.

F. B. Schneider, USA

1663. Morris, J., Torque and flexural stability of a cantilever. Extension of the Bernoulli-Euler theory of bending to cover the whirling of shafts transmitting power, *Aircr. Engng.* **23,** 274, 375–377, Dec. 1951.

Solution of fundamental differential equations (3), (4) seems incorrect. Work by W. Hunter ["The deflection of a cantilever bar rotated under end load," *Proc. Camb. phil. Soc.* **29,** 423–439, 1933] could be easily extended to this problem.

Roy C. T. Smith, Australia

1664. Javorik, L., Dimensioning of cableway traction ropes (in Hungarian), *Magyar Közlekedés, Mély- és Vizépités* **2,** 12, 55–61, Dec. 1950.

Article deals with a method of determining the forces produced in the traction rope and, particularly, the differences in force appearing at both sides of the driving pulley. After a computation of the driving performance there follows a description of the forces produced in the traction cables. Traction cables must be dimensioned according to the occurring bending stress. All these calculations are established for six basic cases of cableway transportation: (I) Transportation to higher levels. In this case, the driving mechanism is installed at the top and the stretching mechanism on the opposite side at the bottom. Author elaborates a formula for the dynamic and static determination of the stretching weight (not dealt with by Findeis). (II) Transportation downward with driving at the top and stretching at the bottom. (III) Transportation upward with driving mechanism below and stretching at the top. Author asserts and proves that the formulas established by Findeis in this respect are erroneous. Author elaborates new formulas and gives the derivation. (IV) Transportation downward with the driving mechanism below and stretching at the top. In this regard, also, the Findeis formulas are erroneous, in place of which new ones have been elaborated and the derivations indicated. V and VI are not dealt with by Findeis. These refer to cases where the driving as well as the stretching are affected in the valley station. In this event, the stretching weight stretches the descending rope. In this connection the investigations extend to upward carriage (V) and downward carriage (VI). These cases are discussed from an economical aspect, and, finally, computations are given on the dimensioning of traction ropes and are illustrated by practical examples.

Courtesy of Hungarian Technical Abstracts

Plates, Disks, Shells, Membranes

(See also Revs. 1637, 1653, 1655, 1656, 1688, 1701, 1711)

1665. Stein, M., and Mayers, J., A small-deflection theory for curved sandwich plates, *NACA Rep.* 1008, 6 pp., 1951.

See AMR **4,** Rev. 625.

1666. Hermes, R. M., On the inextensional theory of deformation of a right circular cylindrical shell, *J. appl. Mech.* 18, 4, 341–344, Dec. 1951.

Inextensional deformations of a circular cylindrical shell loaded by a symmetrically placed pair of concentrated compressive forces applied at opposite ends of a diameter has been considered by Rayleigh and by Timoshenko. Using superposition, author extends the inextensional results to the case of a pair of diametrically opposite plane line loads which are symmetrical about a mid (circular) cross section. Author deduces that such a distributed symmetrical plane load system "should produce the same displacements whether it is uniformly distributed along the entire length of the two diametrically opposite generators, or only along, say, the middle third of these elements."

Author had two loading cases tested by Butier, Pearce and Teniera: (1) Uniformly distributed compressive line load applied along the middle third of two opposite generators; (2) a pair of equal concentrated compressive forces applied at each end of the middle third of two opposite generators.

In general, the discrepancy between theoretical predictions and experimentally obtained strain results was considerable. For the maximum circumferential strain, the difference was 37% and 46%, respectively, for the loadings (1) and (2).

Author concludes that "the theory of inextensional bending of cylinders is open to considerable doubt and (that) any solution based upon this theory warrants experimental verification before acceptance."

This conclusion is open to question. The correctness of the theory is not open to doubt, although its applicability may be. This latter is not shown here, however, as author used a 3-ft cylinder of 8-in. diam by $^1/_4$-in. wall thickness. The thickness to radius ratio is thus 1:16, whereas the ratio usually recommended as the field of applicability of inextensional bending is 1:300, and more preferably about 1:1000.

F. S. Shaw, USA

1667. Parkus, H., The basic equations of the general cylindrical shell (in German), *Öst. Ing.-Arch.* **6,** 1, 30–35, 1951.

In an earlier paper [AMR **4,** Rev. 629], author derived general linearized differential equations for thin elastic shells in tensor form. Thermal stresses are included. In this paper, author specializes the equations for noncircular cylindrical shells with arbitrary variation of thickness. Results are expressed without tensor notation.

H. L. Langhaar, USA

1668. Craemer, H., Influence of transverse bulkheads on stresses in closed shells consisting of flat walls (in German), *Schweiz. Bauztg.* **69,** 44, 613–614, Nov. 1951.

Assuming rigid bulkheads, problem is discussed in general terms. Application is made to water tower of octagonal cross section under wind loads. Results show that effect of bulkheads is a tendency of stress distribution to approach Navier theory.

F. J. Plantema, Holland

1669. **Kuenzi, E. W., Edgewise compressive strength of panels and flatwise flexural strength of strips of sandwich construction,** *For. Prod. Lab. Rep.* no. 1827, 11 pp., 3 tables, 9 figs., Nov. 1951.

Author compares experimental results of edgewise compressive and flatwise flexural tests on specimens of sandwich construction to theoretical values [*FPL Reps.* 1583B, Nov. 1950, and 1817, Aug. 1950]. Variables investigated include thickness of skin and core construction. Correlation of results on compressive loading is very good; that for the flexural tests shows somewhat greater scatter. Major causes of variations in flexural tests are attributable to defects in sandwich construction, such as poor adhesion of skin to core material. Frank J. Mehringer, USA

1670. **Gerard, G., Linear bending theory of isotropic sandwich plates by an order of magnitude analysis,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-31, 3 pp. = *J. appl. Mech.* **19**, 1, 13–15, Mar. 1952.

By use of an order-of-magnitude analysis, the equilibrium and stress-strain relations for the faces and core of a sandwich plate are examined in terms of the thickness of the plate. The analysis results in a set of simplified stress-strain relations for the sandwich plate, in addition to which the basic assumptions of previous sandwich-plate bending theories are obtained as the end result.

From author's summary by Frank J. Mehringer, USA

1671. **Hickman, W. A., and Dow, N. F., Direct-reading design charts for 75S-T6 aluminum-alloy flat compression panels having longitudinal extruded Z-section stiffeners,** *NACA TN* 2435, 60 pp., Feb. 1952.

Direct-reading design charts are presented for 75S-T6 aluminum-alloy flat compression panels having longitudinal extruded Z-section stiffeners. These charts, which cover a wide range of proportions, make possible the direct determination of the stress and all panel dimensions required to carry a given intensity of loading with a given skin thickness and effective length of panel.

From authors' summary

1672. **Steele, M. C., Partially plastic thick-walled cylinder theory,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-25, 8 pp.

First half of paper reviews previous solutions for plane strain cylinders. Author concludes that such simplifications as taking $\nu = 0.5$ (incompressibility), and using Hencky (deformation) theory are justified for engineering usage. Second half presents solution in closed form for open-ended cylinder under following assumptions: Extension of Tresca's yield condition to cover strain-hardening, incompressible material, deformation theory.

Philip G. Hodge, Jr., USA

1673. **Esslinger, Maria, Static calculation of heads for pressure vessels [Statische Berechnung von Kesselböden],** Berlin, Springer-Verlag, **1952**, viii + 100 pp. DM 10.50.

This monograph deals primarily with elastic analysis of torispherical heads for pressure vessels. Head is assumed to consist of a spherical segment attached to a cylindrical shell by a torus segment (knuckle). For calculating the spherical segment in normal heads, assumption is made that opening angle is less than 60°; in this case, the differential equation involved becomes much simpler. Knuckle is assumed divided into a number of short segments, each of which is treated separately. Cylindrical portion is calculated using known equations for cylindrical shells. From consideration of deflections and angular rotations of various elements, sufficient equations are obtained to determine unknown moments and forces. A numerical example is worked out in considerable detail to illustrate this method. Both welded and riveted heads are considered, while comparison is made between test results and calculated values. Spherical heads convex to pressure are also treated as well as manhole openings with flanges. A general discussion of distribution of normal forces, tangential forces, and bending moments is also given on the basis of calculated results. Book should interest designers of pressure vessels.

A. M. Wahl, USA

1674. **Chadaya, F. G., Investigation of the stability of a rectangular plate of variable thickness by the method of finite differences** (in Russian), *Trudi Tbiliss. Mat. Inst. Razmadze* **17**, 191–201, 1949.

S. E. Mikeladze [e.g., *Akad. Nauk SSSR Prikl. Mat. Mekh.* **12**, 219–222, 1948], has developed a general method of solving by finite differences the differential equations with boundary conditions of applied mechanics. The author used this method for finding the coefficient of stability of a thin rectangular plate hinged on the edges. The plane of symmetry of the plate passes through the (x, y)-plane and two edges coincide with the x and y axes, respectively. The variable thickness of the plate is a function of y and the plate is compressed along the edges parallel to x axis. The author compares his results with those for a square plate with constant rigidity, given by S. P. Timoshenko ["Theory of elastic stability," McGraw-Hill, New York, 1936]. The agreement is good. The author also claims that the method of finite differences is simpler and requires fewer computations than the one shown by P. F. Pankovich ["Applied mechanics of a ship," vol. II, Leningrad, 1941 (Russian)].

Courtesy of Mathematical Reviews T. Leser, USA

1675. **Kerkhof, W. P., New stress calculations and temperature curves for integral flanges,** 3rd World Petr. Congr., The Hague, 1951. Proc. sec. VIII, pp. 146–168.

The occurrence of leakage in flanges at room temperature and higher temperature up to the temperature that creep becomes significant is studied. The bolt load decreases with increasing temperature. The bolt load can be calculated with the aid of the formula of Petri and Watts, which is a very good approximation. There is a difference between flanges for covers and flanges for connecting pipe lines on which an external bending moment acts due to thermal expansion. The stress calculations are quite in agreement with the tests carried out. It is found that the high stresses in the shell may have values up to the yield point. A safety factor of 1.2 relative to the yield point at room temperature is recommended. The flanges calculated by the recommended method will be thinner than flanges calculated by the normal formulas. Temperature curves for the calculation of the necessary bolt loads are developed. The calculation by the approximate method is given in a simple scheme.

Ludwig Föppl, Germany

Buckling Problems

(See also Rev. 1674)

1676. **Stowell, E. Z., Heimerl, G. J., Libove, C., and Lundquist, E. E., Buckling stresses for flat plates and sections,** *Proc. Amer. Soc. civ. Engrs.* **77**, Separate no. 77, 31 pp., July 1951.

In an excellent survey of experimental and theoretical results on elastic and plastic buckling of plates and sections under compression, shear, and their combination, it is concluded that there is good agreement between theory and experiment for all engineering purposes. The buckling stresses are given as a nondimensional chart for the elastic stress range, and their relationship to maxi-

mum strength is exhibited. There is a brief discussion of the theoretical and experimental techniques relating to the problem.

B. R. Seth, India

1677. Stowell, E. Z., and Pride, R. A., The effect of compressibility of the material on plastic buckling stresses, *J. aero. Sci.* **18,** 11, p. 773, Nov. 1951.

Note in Readers' Forum.

1678. Krall, G., Stability of elastic equilibrium (in Italian), *Ann. Mat. pura appl.* **29,** 77–90, 1949.

Various known criteria used in the analysis of the instability of elastic systems are developed from the fundamental principle of Dirichlet on the equilibrium of conservative systems. Certain specific examples of elastic stability problems are discussed in detail.

H. G. Hopkins, USA

1679. Cicala, P., Approximate method for the analysis of elastoplastic buckling (in Spanish), *Monogr. Lab. Aero. Polit. Torino,* 15 pp. = *Rev. Fac. Cienc. Exact. Fis. Nat. Cordoba* **14,** 1, 1951.

The relationships between the increase in load and the corresponding increases in bending moment and curvature during buckling of beams (according to the Shanley theory) are derived under the assumption that the difference between the elastic and the tangent moduli is small. These relationships are used to determine the variation of the plastic region with the load and the variation of the center deflection with the load for a simply supported I-beam. The results agree favorably with a rigorous solution of the same problem obtained by author for $E_t/E = 2$, indicating that the approximate theory is valid even if E_t is substantially larger than E. The approximate theory can be applied to any beam with symmetrical cross section. An outline of the extension of the approximate theory to two-dimensional buckling is added.

M. G. Salvadori, USA

1680. Nowiński, J., Problem of stability of high-plate-girder webs (in Polish), *Inżyn. Budown.* **8,** 5, 208–216, May 1951.

Author deals with the problems of stability of high-plate-girder webs. Paper contains a discussion of the well-known Timoshenko, Chwall, Nölke, and St. Bergman solutions. Author presents approximate formulas for determining critical stresses, and deals with strains and stresses of a plate in a supercritical condition.

Finally, on the basis of Wästlund's and St. Bergman's experiences, the safety factors proposed by them for buckling of plates are discussed and compared with the factors adopted in the Polish standards for steel constructions.

W. Nowacki, Poland

Joints and Joining Methods

1681. Norén, B., Strength of bolted wood joints, especially the influence of washers' size on strength and stiffness in single shear (in Swedish), *Sven. TraforskInst. Medd.* 22B, 42 pp., 1951.

In this report, two-member bolted joints are treated both experimentally and theoretically (type of joints as described under 600-L-2 and 600-L-3 in National Design Specific. for stress-grade lumber and its fastenings, rev. 1950, Washington, D. C.). Two special cases of bolts are discussed, (1) with free ends, (2) ends restrained with washers. Indentation of the bolt into the wood is found both experimentally and theoretically, and relationships are established between thickness of timber, bolt diameter, and modulus of elasticity of steel. Tests prove that: (a) Slight change of the bolt axis due to bending affects but slightly the bearing capacity; (b) for case (2) the simple relationship was found: working load in lb = $^1/_{10}$ of compressive strength of wood × thickness of the timber × bolt diameter (in inches) assuming factor of safety 3; (c) tables and charts indicate the effect of various types of washers; (d) specific capacity of slender bolts is greater than the bearing capacity of heavy bolts.

J. J. Polivka, USA

1682. Kreisle, L. F., and Oliphint, J. B., Bolt elongations and loads, Ann. Meeting ASME, Atlantic City, Nov. 1951, Paper 51—A-49, 12 pp.

A poorly written paper that does not appear to add much to the topic. Some of the assumptions made, especially that of gasket deflection, do not seem especially valid and tend to vitiate the equations derived. Descriptions of experimental techniques are completely lacking. Aside from calling attention to some of the difficulties involved in the problem, paper does not add much to current knowledge.

F. L. Singer, USA

1683. Reinhart, F. M., Hess, W. F., Wyant, R. A., Winsor, F. J., and Nash, R. R., Mechanical and corrosion tests of spot-welded aluminum alloys, *NACA TN* 2538, 74 pp., Dec. 1951.

Authors report results of the effect of spot-weld quality on corrosion resistance (to marine atmospheres and tidewater) and mechanical properties of R-301-T6, Alclad 24S-T3, Alclad XB75S-T6, 24S-T3, and XB75S-T6. Materials studied were all 0.040 in. thick or less.

Among the variables studied was the method of surface preparation. The effects of internal and external cracks, expelled metal between the faying metal surfaces, and dirty surfaces caused by dirty electrodes were investigated. A study was also made of the effects of anodizing and painting. Welds were radiographed prior to exposure and testing. Following exposure to corrosive attack, mechanical tests were carried out and comparisons made with specimens protected from corrosion. Metallographic examination was also conducted.

Spot-welded Alclad 24S-T3, Alclad XB75S-T6, and R-301-T6 are generally satisfactory for use in marine atmospheres and for intermittent wetting by sea water for periods of time between one and three years. Spot-welded and anodized 24S-T3 requires additional protection, and unprotected spot-welded XB75S-T6 is not recommended for use under marine conditions.

Conclusions are also reported on effect of corrosion on strength of spot welds.

Carl A. Keyser, USA

1684. Wasserman, R. D., and Quaas, J., Dilution and diffusion aspects of nonfusion welding, *Weld. J.* **30,** 12, 1098–1101, Dec. 1951.

Authors present a general discussion of diffusion theory. Reference is made to the importance of diffusion processes in nonfusion welding or brazing. In reviewer's opinion, article is rather obscure with regard to application of physical chemical theories and thermodynamic data to provide a better understanding of the brazing processes.

Frederick J. Winsor, USA

1685. Mack, J. J., Tests on the holding power of special nails in radiata pine, *Austral. J. appl. Sci.* **2,** 4, 454–463, Dec. 1951.

Tests have been carried out on 15 types of nails to determine and compare their static and impact holding powers in radiata pine. Treated nails were superior to plain nails.

Other tests show that the moisture content of the timber at the time of driving had only a slight effect on the holding power, but that the effect of the timber drying out after driving was considerable.

From author's summary

1686. **Findley, W. N., Century, B. A., and Hendrickson, C. P., Fatigue tests under axial loads of aluminum joints bonded with a resinous adhesive,** *ASTM Bull.* no. 179, 67–71, Jan. 1952.

Single-lap, double-lap, and butt joints were tested in an axial-load fatigue machine. The methods of testing, the merits of the three procedures employed, and the test results obtained are discussed. The fatigue strength at 10^7 cycles was found to be about three times as large for the butt joints as for the lap joints.

From authors' summary by F. R. Shanley, USA

©1687. **de Bruyne, N. A., and Houwink, R., Adhesion and adhesives,** New York, Amsterdam, London, Brussels; Elsevier Publ. Co., 1951, xv + 517 pp. $10.

The editors and authors of this book have performed a badly needed service in collating and sifting the mass of published material in the field of ahesives, bringing it together in this well-planned and executed volume. Individual chapters are written by American and European authorities, including the editors, so that minor discrepancies in terminology are to be expected, but these do not detract from its value. Two major divisions are found; the first devoted to theoretical aspects including general conditions for adhesion, molecular forces, rheology, and static problems; the second to technological aspects including the various organic, inorganic, synthetic, and naturally occurring adhesives, and to testing.

For the research worker and the engineer using and testing adhesives, the book is equally valuable and very nearly indispensable as a ready source of information and exposition of theory and practice in this complex field.

Albert G. H. Dietz, USA

1688. **Esslinger, Maria, Calculation of pipe connections** (in German), *Stahlbau* **20**, 10, 11; 120–123, 133–136; Oct., Nov. 1951.

The calculation of connecting pipes is a task which gains importance with increasing pressure and dimensions of pipes. Author treats the pipe connection with its axis perpendicular to the pipe axis. She assumes that the socket entirely takes up the membrane stresses on the edge of the cutting so that the joining pipe shell is not additionally strained. The calculation takes the spatial shape and variable rigidity of the flange into consideration and is, therefore, rather troublesome. Simple and useful formulas for approximate calculations are given. It is to be regretted that calculation of the welding is not shown simultaneously.

Pavel Kohn, Czechoslovakia

Structures

(See also Revs. 1617, 1660, 1661, 1668, 1669, 1680, 1710)

1689. **Lightfoot, E., A method of analysis of the continuous Vierendeel girder,** *Struct. Engr.* **29**, 11, 293–296, Nov. 1951.

Method consists of determining influence lines for redundant reactions by calculating corresponding deflection line for same girder except that redundant reactions have been removed. Two numerical examples are given and results compared with those obtained by Takebeya and Uchida, who used the slope-deflection method.

Dana Young, USA

1690. **Grioli, G., Elastic equilibrium of bridges** (in Italian), *Ingegnere* 11–12, Nov.-Dec. 1949 = *Cons. Naz. Ric.* no. 259, 16 pp., 1950.

M. Picone proposes to solve problems of plain stress by developing the solution into a series of polynomials with respect to displacement, satisfying the differential equations exactly and the boundary conditions (by application of Betti's theorem) approximately. This idea is applied to the problem of a concrete bridge with a load varying so slowly that in the cross section, limited by 3 straight lines and 1 parabola, a state of plain diagrams shows the bending line and, by means of isostatics obtained analytically, the stress distribution, which is of importance chiefly for reinforcing the concrete.

K. Marguerre, Germany

1691. **Chen, S.-T., Secondary stresses in bridge trusses,** *Proc. Instn. civ. Engrs.* **1**, 1, 95–104, Jan. 1952.

Paper suggests simple rules for obtaining initial approximation to joint rotation in analysis of secondary stresses by slope deflection method and for obtaining an initial carry-over in moment distribution analysis. Author asserts that these rules lead to convergence in fewer cycles than usual assumption of equal rotations in slope-deflection method or zero rotations at far ends in moment-distribution method. Illustrative examples are presented.

Reviewer believes that slope-deflection practice of assuming all angles equal in order to obtain initial guesses for alternate joints is, in general, sufficiently good; that chief merit of paper is the suggested initial carry-over which brings moment-distribution method into line with slope deflection; and that experienced engineers are able to make even better initial guesses using the coefficients of the basic slope-deflection equations as a guide.

John E. Goldberg, USA

1692. **Chu, K.-H., Truss deflections by the coordinate method,** *Proc. Amer. Soc. civ. Engrs.* **77**, Separate no. 54, 20 pp., Jan. 1951.

The method presented here is an algebraic solution of the Williot-Mohr diagram. By suitable arrangement in tabular forms, and by adopting a set of simple sign conventions, the work is minimized in such a manner as to make this method preferable to the graphical method.

From author's summary

1693. **Stucky, A., Panchaud, F., and Schnitzler, E., Contribution to the study of arch dams. Influence of the elasticity of the supports** (in French), *Bull. tech. Suisse Rom.* **76**, 7, 9, 12, 26; 81–91, 109–115, 149–158, 349–351; Apr., May, June, Dec. 1950.

Until some years ago, arch dams were calculated assuming rigid rock foundations. Paper shows the necessity of considering deformations of the rock, exposing in detail the calculation of a thin-walled arch dam formed by superimposed independent elastic horizontal arch rings, of circular form, with yielding foundations. Paper reviews the classic theory of elastic thin circular arches with fixed ends, under uniform hydrostatic pressure, giving Ritter's formula for the statically indeterminate reaction applied to the elastic center of the arch: $\Delta X_0 = K_0 pr$, where p is hydrostatic pressure, r external radius of arch, and K_0 a coefficient depending upon the central angle 2α and the ratio $\lambda = r/e$ between center-line radius and thickness of the arch. With the symbol σ^* for the "relative normal stress," defined as the ratio between real stress σ and uniform stress $\sigma_0 = R/e$ (thin-walled cylinder), and utilizing the classic relations $\sigma_i^* = F(\lambda, 2\alpha)$; $\sigma_e^* = F(\lambda, 2\alpha)$, ... [1], where σ_e^*, σ_i^* is relative normal stress at, respectively, the upstream and downstream face of the arch at a given section, the authors consider [1], for a given 2α, as a system of parametric equations of a curve whose orthogonal coordinates are σ_i^* and σ_e^*, with the variable parameter λ. The locus of points representing the state of normal stresses distribution over a section defined by a given central angle θ, for different arches with same central angle (λ variable), is an ellipse whose principal axes are easily determined. Once the stresses for uniform hydrostatic pressure are found, the effects of tempera-

ture change may be calculated in a simple way. The influence of the elasticity of the supports is considered by adding to the statically determined structure, previously calculated as a thin-walled cylinder, a force ΔX applied this time at a point called by the authors, "elastic center of the system arch-foundation," and whose coordinates depend upon the geometrical and mechanical conditions of the arch and of the rock. The expression for ΔX is $\Delta X = KR$, formally the same as for ΔX_0, where K is not only a function of λ and 2α but also depends upon the ratio n between the "moduli" of elasticity of the rock and the concrete, and upon the coefficients of the known formulas of F. Vogt ["Ueber die Berechnung der Fundamentdeformation," Norske Videnskaps-Akad., Oslo, 1925; "Engineering for dams," Creager-Justin-Hinds, New York, 1945].

In the case of uniform hydrostatic pressure the equations for the relative normal stresses at a given section are of the type $\sigma_i^* = \varphi_1 (\lambda, 2\alpha, n)$; $\sigma_e^* = \varphi_2 (\lambda, 2\alpha, n)$.

For n and 2α constants, they are parametric equations of an algebraic curve, no more an ellipse. Paper presents three graphics ($2\alpha = 60°$, $90°$, and $120°$), each one for two sections (crown and abutment), for values of n beween 0 and ∞.

Finally, a method of determining the components of deflections at any point of the arch is explained, to serve as a basis for the division of loading between the two systems of elements (horizontal arches and vertical cantilevers) when their interaction is to be considered, a study the authors promise to develop in a future paper.

Though limited to arches of circular form, the method explained is useful for the selection of the preliminary form to start the trial method.

Reviewer believes the most interesting and original part of the paper lies in the idea of establishing a one-to-one correspondence between states-of-stresses distribution over a section and points of a plane, which presents following advantages: Possibility of simultaneous determination of stresses at the upstream and downstream faces; classification of arches under the viewpoint of quality; previous elimination of arch forms not adapted to working conditions, hence, reduction of the number of trials.

Ivo Wolff, Brazil

1694. Kanai, K., Destruction system of building by earthquake, *Bull. Earthq. Res. Inst., Tokyo Univ.* **29,** part 2, 393–401, June 1951.

The motion due to an earthquake is assumed to be sinusoidal at constant frequency. The response of the building structure to such a stimulus is studied. The building is treated as a single degree-of-freedom system with damping. As such, its response could have been evaluated in terms of the equations and parameters commonly used in vibration isolation and described by Den Hartog in his book "Mechanical vibrations," or Timoshenko in "Vibration problems in engineering." Author sets up the equations of motion from first principles with all structural characteristics appearing in fundamental form, such as bending stiffness, column length, etc., instead of being summarized in terms of derived parameters such as natural frequency, equivalent static deflection, etc. This greatly complicates the appearance of the equations and makes reading somewhat difficult.

It is concluded that if failure occurs in a building, it is likely to take place at resonance. However, after initial failure has occurred, the stiffness of the building decreases and the response may become greater (resulting in total destruction) or less (with no further damage), depending upon the amount of damping present.

The justification of treating the earthquake as simple harmonic motion is not discussed. However, using reasonable estimates for the damping in buildings on different types of foundation and of different kinds of construction, positive conclusions have been drawn regarding the type of damage that might be expected. These conclusions have been compared with actual damage occurring in the Kwanto earthquake of 1923. Some degree of correlation was obtained, but it cannot be specified quantitatively, and reference is necessary to the charts and data of the original paper.

C. Desmond Pengelley, USA

1695. Drucker, D. C., Prager, W., and Greenberg, H. J., Extended limit design theorems for continuous media, *Quart. appl. Math.* **9,** 4, 381–389, Jan. 1952.

The limit-design theorems first proposed by authors for a Prandtl-Reuss material subject to surface tractions or displacements which increase in ratio, and applied by them to rigid framed structures and later to problems in plane strain, are here extended to continuous media of perfectly plastic material under any history of loading. Collapse is defined as the condition at which plastic flow occurs under constant applied loads, with the restriction that it is admissible to satisfy equilibrium conditions for the undeformed rather than for the deformed configuration of the body. This restriction gives accurate values for the collapse load except for problems in which buckling (i.e., a large alteration to the geometry of the body) occurs. The boundary conditions discussed are of the stress type; at each point of the surface either the component of surface traction is specified or the displacement component is prescribed to be zero.

A statically admissible state of stress is defined as one which satisfies both equilibrium and boundary conditions for the body; such a state is *safe* if the yield condition is nowhere violated. A kinematically admissible velocity field is defined as one for which the velocity components vanish on those portions of the surface where the surface tractions are not specified; such a field is a *state of collapse* if the rate at which the surface tractions and body forces do work on the velocities exceeds the rate of dissipation of energy computed from the strain rates associated with the velocity field.

From these definitions and the assumption of a convex yield surface, authors state and prove several lemmas and the following theorems: (1) All stresses are constant during collapse; (2) if a safe statically admissible state of stress can be found at each stage of loading, collapse will not occur under the given loading schedule; (3) the converse of (2); (4) if a kinematically admissible collapse state can be found at any stage of loading, collapse must impend or have taken place previously; (5) addition of material to the body cannot decrease the collapse load; (6) increasing the yield strength of the material in any region cannot weaken the body; (7) initial stresses or deformations have no effect on collapse.

Theorems (2) and (4) provide a powerful method of bounding the value of the collapse load from below and above, and the paper establishes the proper theoretical foundations for a large class of practical problems in limit design.

Jacques Heyman, England

1696. Greenberg, H. J., and Prager, W., Limit design of beams and frames, *Proc. Amer. Soc. civ. Engrs.* **77,** Separate no. 59, 12 pp., Feb. 1951.

See AMR **3,** Rev. 2273.

1697. Blakey, F. A., A study of the ultimate flexural strength of reinforced-concrete beams, *Austral. J. appl. Sci.* **2,** 3, 344–357, Sept. 1951.

Author reviews the theory as presented by earlier writers and selects the rectangular compressive-stress block concept for computing the strength of test beams. Computed and observed

strengths are tabulated for 24 beams. For 12 beams, theoretical and observed strengths agree within 10%, and for four additional beams the agreement is within 20%. In this latter group, it might be noted that one beam was heavily overreinforced and the other three contained rather low-strength concrete (1085, 1311, 1850 psi). The remaining six beams showed observed strengths ranging from 40 to 76% above computed values. In reviewer's opinion, this discrepancy is unacceptable, particularly since all six specimens were underreinforced, i.e., were in the range where the theory is most reliable. Author offers as possible explanations: (a) Actual moments may have been affected by horizontal components of support reactions; (b) actual steel stresses may have exceeded yield values based on tensile tests. (Reviewer suggests that the number of samples tested in tension may have been inadequate. It is desirable to have tensile test information for every bar.)

Author's conclusions are in general agreement with those of earlier writers. M. J. Holley, Jr., USA

1698. **Carroll, P. J., The factor of safety as applied to reinforced concrete design,** *J. Instn. civ. Engrs.* no. 9, 491–501, Nov. 1951.

The increased factor of safety (for live load) that automatically results from larger ratios of dead load to live load used with a fixed design stress is discussed. The author proposes to reduce this variation by using only a portion of the dead load (68% suggested) in calculating member sizes. This is equivalent to using dead-load stresses of about 150% of those for live load. The increased deflections that would result are discussed.

Phil M. Ferguson, USA

1699. **Koroneos, D. N., Effect of plasticity of reinforcement on strength of reinforced-concrete sections** (in Greek), *Tech. Chronika, Athens* **28**, 327/328, 258–274, Sept./Oct. 1951.

This is the first of a series of articles taken from a dissertation on an exact method of determining breaking load and factor of safety of reinforced-concrete sections. R. Salinger's approach is used for the case of simple bending of orthogonal sections with plain reinforcement, but a new method is developed applicable to reinforcements possessing any type of stress-strain relationship. Cases of eccentric loading, double reinforcement, and other types of orthogonal sections are solved. Next, T-, rhombic, and the general case section are worked out. In all these, in addition to the load effect, the effects of concrete contraction and deformation are considered.

As different factors of safety are required for concrete and reinforcement, a detailed study of the meaning of these and effect of each on the relationship between allowable load and breaking strength of the composite section is presented. Finally, practical examples are given on the most economical ratio and distribution of reinforcement to concrete.

Dimitri Kececioglu, USA

1700. **Pickett, G., Raville, M. E., Janes, W. C., McCormick, F. J., Deflections, moments and reactive pressures for concrete pavements,** *Kansas State Coll. Bull.* no. 65, 73 pp., Oct. 1951.

Authors have considerably extended the solution of equations pertaining to large concrete slabs supported on subgrades assumed to behave as a dense liquid or an elastic solid of finite or infinite thickness. The work previously done by H. M. Westergaard, A. H. A. Hogg, and others, has been carried to the extent of giving numerical tabulations of the results and preparing 24 charts for graphical evaluation of quantities for desired combinations of loading.

The assumption of a constant modulus of subgrade reaction for the elastic solid subgrade, based on Poisson's ratio of 0.4, appears to be in good agreement with the results obtained by other investigators from plate-bearing tests.

Michael V. Smirnoff, USA

1701. **Guyon, Y., Prestressed concrete [Béton précontraint],** Paris, Editions Eyrolles, 1951, xii + 702 pp.

This rather comprehensive treatment of the theory and experimental work in regard to simple prestressed-concrete structures as developed in France is divided into three parts. The first part is a discussion of the principles of prestressed concrete, the materials of which it is made, and the necessary tools for prestressing; also, test results including fire-resistance tests are discussed. In the second part, the elastic theory is used as a basis for the development of the equations for analysis and design. Many illustrative examples are given. In the third part, author selects for discussion from the numerous tests which have been made, certain typical tests, and concludes with a discourse on factor of safety and the plastic theory. The numerous equations, numerical examples, test results, and tables make this a valuable treatise.

Reviewer believes that anyone who can read French and is interested in prestressed concrete will find this book well worth studying, even though it does not describe some of the latest devices used in the United States.

Robert B. B. Moorman, USA

1702. **Tremmel, E., Contribution to calculation of masonry vaults** (in German), *Z. Öst. Ing.-Arch. Ver.* **96**, 19/20, 21/22; 161–164, 187–189; Oct., Nov. 1951.

Paper is mainly intended to improve computation of thick circular arch dams in which ratio of thickness to radius of curvature is not negligible. Plane cross sections (in reviewer's opinion, better called plane strain distribution), after bending, are assumed, which leads to the well-known hyperbolic stress distribution and a neutral axis not coinciding with the centroid. If, then, the normal force is not applied in the centroid but in the position of the neutral axis as occurring under pure bending, it will produce only a change in length of the element but no angle change between two adjoining cross sections. As a main system, two circular cantilevers are adopted and unknowns applied at elastic center. Computation then is formally as in thin-arch theory. Formulas are given for deformations due to unknowns, hydrostatical load, and temperature gradient. Hereby, a hyperbolic temperature distribution across the section is assumed, since it produces a linear temperature strain.

H. Craemer, Germany-Egypt

1703. **Hendry, A. W., The plastic design of two-pinned mild steel arch ribs,** *Civ. Engng. Lond.* **47**, 547, 38–41, Jan. 1952.

Author applies the plastic theory to arch ribs of parabolic shape, and discusses the mode of failure of two-pinned arches. Some results are given from tests on model arches. A semi-graphical procedure is introduced as a convenient method of determining the collapse load. Reference is given to the design of a 70-ft span parabolic arch. C. J. Bernhardt, Norway

1704. **Button, S. J., Statistical analysis of the stability of foundations,** *Civ. Engng. Lond.* **46**, 545, 840–842, Nov. 1951.

A given example of test results is examined. Mean, standard deviation, and confidence limits are computed elaborately. For borings at variable depths, the linear correlation between strength and depth, as well as the corresponding confidence limits, are derived. The influence of the number of test results upon confidence limits and, therefore, reliability of results is emphasized. Factor of safety is proposed to be based on statistical considerations. H. Craemer, Germany-Egypt

1705. Newmark, N. M., Siess, C. P., Viest, I. M., Tests and analysis of composite beams with incomplete interaction, *Proc. Soc. exp. Stress Anal.* **9, 1,** 75–92, 1951.

The effects of an imperfect connection between the two elements of a composite beam are considered in this paper. Tests of six composite steel and concrete T-beams are described, and a theoretical analysis is presented for the general case of beams consisting of two interacting elements. Load-slip characteristics, which must be determined as a basis for the theoretical analysis, were studied by means of pushout tests of steel channel-shear connectors embedded in concrete. Results of the T-beam and push-out tests are compared.

The theoretical analysis is based on the assumption that a continuous imperfect connection exists between the two separate elements. A differential equation for the force transmitted through the shear connection is derived and is solved for the case of a beam loaded with concentrated load. Expressions for the slip, shear between interacting elements, strains, and deflections are given.

The test results are compared with those given by the theory for incomplete interaction. All of the beams tested had shear connectors of practical proportions and, consequently, had a degree of interaction such that the theoretical values for complete and incomplete interaction differed only slightly. However, the test results are generally in good agreement with the theory.

From the author's summary by Bruno A. Boley, USA

1706. Moore, R. L., and Shaw, J. R., Pressures in a shallow rectangular bin, *Proc. Amer. Soc. civ. Engrs.* **77,** Separate no. 82, 13 pp., Aug. 1951.

The lateral bulging pressures indicated by the loose granular loadings (before vibration) were generally somewhat higher than those computed by the Rankine formula, using accepted values of angle of repose. The lateral pressure produced by any given granular material may vary over quite wide limits, depending on the manner in which the container is loaded and on whether the material, after being placed, is compacted by impact or vibration.

In the design of shallow containers where vibration is known to be a factor, it is proposed that the lateral bulging pressure be taken as 60% of that computed for a fluid having the same weight as the granular material considered. The bottom of such containers should be designed to carry the full weight of the loading.

The measurements on the bottom of the bin indicate that the structural action of the panels between stiffeners was complicated considerably by the initial waviness of the sheet. Since this is a common characteristic of thin-walled, welded containers, it appears that attempts at refined or exact analyses of the bending action of side or bottom panels under small normal pressures are not justified. The analysis of the observed behavior of the vertical stiffeners and the top rail (which were the basic strength elements of the bin) indicate the importance of such considerations as effective widths of sheet, restraint, and load distribution in the design of members of this type.

From authors' summary

1707. Kerr, P., The expansion of vertical cylinders under liquid head, *J. Inst. Petrol.* **37,** 336, 740–748, Dec. 1951.

Due to the weight of liquid in a large vertical storage tank, there will be an increase in the diameter. The consequent increment in the capacity of the tank is discussed.

G. V. R. Rao, USA

1708. Moliotes, P., Influence lines of hyperstatic frames and the elastic displacements of the supports (in Greek), *Tech. Chronika, Athens* **28,** 327/328, 282–285, Sept./Oct. 1951.

A thorough, tensor-mathematical treatment of the subject is presented for the general case. Dimitri Kececioglu, USA

1709. Baron, F., and Michalos, J. P., Laterally loaded plane structures and structures curved in space, *Proc. Amer. Soc. civ. Engrs.* **77,** Separate no. 51, 33 pp., Jan. 1951.

The column-analogy method applies to loads acting in the plane of a structure or to moments about axes perpendicular to that plane. The shear and torsion analogies developed by authors apply when the loads act normal to the plane of the structure and when moments act about axes in that plane. By extending the three analog methods to apply to three-dimensional structures such as arches, bents, balcony girders, pipe lines, and other odd-shaped systems which are continuous between two supports whether curved or segmental in space, a procedure is developed by which analyses may be made for loads in any direction or moments about any axes.

Considerable study will be required to master all details of the procedure, but tabular methods are given for the computation of quantities pertinent to its application. Illustrative examples indicate its merits in the analysis of an unsymmetrical bent, a symmetrical arch, and a three-dimensional framed structure having three prismatic segments each of which is parallel to one of the three orthogonal axes. The method may be applied to systems having members of varying cross section, or to systems in which the effects of temperature changes are significant, hence is quite general and useful. Joseph S. Newell, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1657, 1672, 1695, 1733, 1737)

1710. Levi, F., and Pizzetti, G., Creep, plasticity and prestressing [Fluage, plasticité, précontrainte], Paris, Dunod, 1951. xvi + 463 pp. 3900 fr. frs.

Authors are to be congratulated on this excellent book. Although the primary intention is to present applications to concrete, many of the parts are applicable to metals as well. This is especially true of the viscoelastic and elastic-plastic theories.

The chapter headings in the three parts of the book are: Part I. Theory of linear creep. Application of the linear creep laws to homogeneous solids. Study of creep effects in heterogeneous bodies. Creep and delayed elasticity. Influence of delayed elasticity upon the equilibrium of viscoelastic bodies. Integration of fundamental equations in certain particular cases. Instability of viscoelastic solids. Experimental verifications of the linear creep theory. Influence of the change of the elastic modulus, which accompanies aging of concrete.

Part II. Theories of failure. Colonnetti's theory. Application of Colonnetti's theory. Bending in the elastic-plastic domain. Combined bending and shear. Torsion. Equilibrium of elastic-plastic hollow cylinders. Equilibrium of elastic-plastic rotating disks. Curved beams. Beam and arch theory. Extension of Hardy Cross method to statically indeterminate systems in the elastic-plastic domain.

Part III. Origins of the prestressing technique. Materials employed in prestressed structures. Prestressed structures. Partially prestressed structures. Design of prestressed beams.

The first part of the book contains an excellent treatment of creep and the theory of viscoelasticity, many parts of which are not available in the literature. The last section contains a rather complete treatment of prestressed concrete which should prove most useful to the designer.

On the whole the book is well written. Mathematical rigor is ever present, and yet the authors have an engineering touch which points the way to applications of the theory. Experimental evidence and numerous references are included. This text is a welcome and valuable contribution to the literature.

Harry H. Hilton, USA

1711. **Freiberger, W., A problem in dynamic plasticity: the enlargement of a circular hole in a flat sheet,** *Proc. Camb. phil. Soc.* 48, part 1, 135–148, Jan. 1952.

The enlargement of a circular hole in a flat sheet is analyzed for perfectly plastic materials. Inertia force is included in the equilibrium equations with the assumption that circumferential stress is taken to be zero in the region around the hole. Illustrative numerical calculations are shown for the case of uniform acceleration in enlargement. The magnitude of the circular shock front, i.e., a discontinuity in thickness and velocity, are determined from conservation of mass and momentum. Step-by-step process for analyzing the case of initial enlargement with uniform velocity followed by constant acceleration is given with curves to illustrate some of the general results. This treatment is analogous to that of one-dimensional compressible gas-flow problems.

T. H. Lin, USA

1712. **Inoue, N., Application of the theory of supersonic flow to the two-dimensional isostatical problem in the theory of plasticity,** *J. phys. Soc. Japan* **6**, 6, 460–465, Nov./Dec. 1951.

With a constant Mach number $(2)^{1/2}$ and with the artificial assumption $p/\log \rho =$ const, author finds equations for the two velocity components in plane supersonic flow identical to those for the three stress components in plane plastic flow. Reviewer feels that this analogy leads in this paper to results in plasticity that can be better reached by the methods described by Hill [AMR **4**, Rev. 2471].

D. R. Bland, England

1713. **de Strycker, R., Creep and relaxation of drawn wires** (in French), ***Rev. Métall.* 48,** 11, 888–893, Nov. 1951.

Relaxation experiments were made in the following manner: The load was reached in not more than 15 sec and remained stable for 2 min. Afterward, the load reduction with unchanged measuring length was examined. Most favorable for the application of Martens' mirror extensometer was a measuring length of 200 mm. At first, the resulting scatterings were examined to determine how far they were due to inexact experimentation and to different material. Further experiments were devoted to the influence of aging. For these tests, wire of quasi-eutectoid steel was used which, through patenting and drawing, had reached a strength of 140–150 kg/mm² and an elastic limit of 110 kg/mm². After artificial aging, such wires show the same relaxation properties with an initial load of 110 kg/mm² in the course of 23 hr as does unprocessed wire exposed to a load of 85 kg/mm². When observation is continued for a longer space of time, however, the relaxation process diminishes more slowly in the case of aged wires than it does in the case of unprocessed wires. When the load extension is compared with the extension corresponding to relaxation, the load extension reaches several times the relaxation extension in the course of one day. Relaxation can be substantially reduced by a short-time overload. The last part of the article compares creep and relaxation under the same initial load. The comparison shows that the relaxation extension is always smaller than the extension under a stable load.

E. Siebel, Germany

1714. **Bailey, R. W., Creep relationships and their application to pipes, tubes, and cylindrical parts under internal pressure,** *Instn. mech. Engrs.* **164**, 4, 425–431, Proc. 1951.

Paper deals with the determination of creep strain-stress relations for states of combined stress. It differs from other available theories in considering not only the secondary creep but also the primary and tertiary creep. For this purpose, the following relation for simple tension is used: $\dot{x} = dx/dt = AX^n x^{-p}$, where $\dot{x}$ is the creep rate, X the stress, x the creep strain, and A, n, and p are experimental constants.

Second part of the paper applies the theory to the stress distribution and creep in thick-walled cylinders subjected to internal pressure. Author also discusses the determination of design temperature to provide for specific temperature and pressure fluctuations. Some discussion is also given on the action of creep in removing the thermal expansion loading of a pipe line.

Joseph Marin, USA

1715. **Brown, A. F., and Honeycombe, R. W. K., Micro-slip in metal crystals,** *Phil. Mag.* (7) **42**, 333, 1146–1149, Oct. 1951.

Small plastic deformation (0.5–2%) of 99.99% pure aluminum single crystals gave extremely fine slip bands if surface was (a) solely electropolished, but gave the familiar coarse bands if (b) mechanical preceded electrolytic polishing. The coarse bands appear with (a) treatment after larger (5%) deformations. The problem to be solved is whether microslips are a manifestation (modified by the nature of the surface) of interior coarser slips or represent initial fine slips in the interior which, because of interference, become almost entirely suppressed as the deformation proceeds.

Hans F. Winterkorn, USA

1716. **Reiner, M., An investigation into the rheological properties of bitumen. I. Maxwell-body and elastic dispersions,** *Bull. Res. Counc. Israel* **1**, 3, 5–25, Aug. 1951.

This theoretical consideration of the rheological behavior of sols and gels has particular reference to viscoelasticity in bitumen, which may exist in the sol and the gel states. Author shows that, although the rheological behavior of sols and gels is indistinguishable for infinitesimal elastic strain, it is markedly different under finite strain. For example, in simple shear an elastic sol exhibits flow curves similar to those for pure deformation, whereas an elastic gel simulates variable viscosity. Accordingly, observations of large deformation of materials which may exist in the sol and gel states may help in arriving at the structure of the material.

The paper acts as an introduction to part II, to follow, which will report experimental work on blown bitumen subjected simultaneously to extension in one apparatus and shear in another.

Stacey G. Ward, England

1717. **Katchalsky, A., and Sternberg, N., A note on the extension of Poiseuille's equation to non-Newtonian liquids,** *Bull. Res. Counc. Israel* **1**, 3, 111–113, Aug. 1951.

The usual Poiseuille relation assumes Newtonian viscosity, and the note describes an attempt to modify the relation to take account of non-Newtonian flow. The viscosity is expressed as a power series and, using some simplifying assumptions, the viscosity at zero velocity gradient and the first term of the series are evaluated for polymethacrylic acid. It is found that the viscosity at zero velocity gradient agrees well with the viscosity from the Poiseuille relation if the data used to determine the latter are extrapolated to zero stress levels.

A. D. Schwope, USA

1718. **Krieger, I. M., and Maron, S. H., Direct determination of the flow curves of non-Newtonian fluids,** *J. appl. Phys.* **23**, 1, 147–149, Jan. 1952.

A result obtained by Mooney [*J. Rheology* **2**, 210, 1931] is carried further, thus facilitating the determination of the rheological curve of a viscous liquid with variable viscosity from consistency curves obtained in a coaxial rotating cylinder apparatus using a number of inner cylinders of different radii. It is shown that two such cylinders are sufficient for a close approximation. Paper constitutes an advance in what Hersey [*ibid.* **3**, 196, 1932] named the "differentiation method" in rheological analysis, similar to what Schofield [*Physics* **4**, 122, 1933] effected for the

capillary viscometer. (The dimension of the velocity gradient is incorrectly given as cm^{-1} instead of $time^{-1}$.)

M. Reiner, Israel

1719. Buchdahl, R., and Nielsen, L. E., The application of Nutting's equation to the visco-elastic behavior of certain polymeric systems, *J. appl. Phys.* **22,** 11, 1344–1349, Nov. 1951.

The Nutting equation for creep at constant stress ($\epsilon = \psi\sigma^{\beta}t^{n}$; ψ, β, and n parameters) is shown to be in better agreement with experiment than that based on a linear four-parameter model of dashpots and springs (comprising instantaneous and delayed elasticity and flow). Significance of the Nutting parameters is discussed. n is associated with the complex modulus on the assumption that relaxation and creep functions are reciprocal. A check of this for polyvinyl chloride at varying temperatures is given, and also of the parameter ψ with 5-sec creep modulus. There is a discussion of the dimensions of the parameters involved.

It seems to reviewer that the preference expressed for the Nutting equation does not take account of the limitation that it is compared with a linear model, and that the linear model predicts behavior under much more general conditions than creep at constant stress and can thus be expected to do this less well. Moreover, the complex modulus concept used to express the Nutting parameters is based on the analysis of a linear model.

E. H. Lee, USA

1720. Gebhardt, E., and Becker, M., Internal friction of liquid alloys of gold-silver (in German), *Z. Metallk.* **42,** 4, 111–117, Apr. 1951.

Torsion pendulum is damped by cylinder suspended below and immersed in the molten metal in hydrogen atmosphere. Viscosity of metal is computed from the damping factor. Metals of known viscosity are used for calibration.

Isotherms of viscosity vs. weight percentage of composition of the Au-Ag melt are smooth curves of small curvature. Metallic compounds therefore do not occur in the Au-Ag system in the molten state. Measured viscosity of Ag at 1200 C agrees with published value. Measured viscosity of Au at melting point checks the Andrade equation. Au, Ag, and their binary alloys obey the viscosity-temperature equation $\ln \eta = A + B/T$, with single value of B.

Melvin Mooney, USA

1721. Gebhardt, E., and Wörwag, G., Internal friction of liquid alloys from copper-silver and gold-copper (in German), *Z. Metallk.* **42,** 12, 358–361, Dec. 1951.

Viscosity measurements with apparatus described (preceding review) are reported for the Au-Cu and the Ag-Cu systems.

Melvin Mooney, USA

1722. Masing, G., The influence of the surrounding medium on the plastic deformation of metals (in French), *Metallurgia ital.* **63,** 11, 467–470, Nov. 1951.

P. Rehbinder [*Z. Phys.* **72,** p. 191, 1931] found that plastic deformation of metallic wires depends on chemical environment. Addition of valeric, stearic, or heptilic acid to pure vaseline oil increased the rate of deformation by factor of 2 or 3. Additions diminish surface tension between metal and liquid and favor increase of surface metal. Authors later verified these results, but attributed them to presence of oxide layer or other corrosion product on primary surface. These layers would give hardening effect, are affected by addition of acid components to vaseline oil but not by the pure oil itself.

Present paper reports systematic experimental study of Rehbinder effect. Deformation under constant load of carefully cleaned wires of different metals (Pb, Zn, Ag, Pt, Au) are measured (a) in air, (b) in electrolyte (NaCl KNO_3) with and without polarization. With gold and platinum wires, both anodic and cathodic polarization were employed, otherwise only cathodic polarization. In all cases, Rehbinder effect was confirmed. Under conditions of the present experiments, in particular with wires of noble metals, presence of oxide layer could be excluded. Thus the former theory is considered unsustainable. A more plausible theory is found in theory of crystalline slip. Slip causes a small increase of surface (without appearance of fissures). It proceeds with an activation energy on which its speed depends. The activation energy can be split up into two terms, one of them referring to surface energy. Chemical environment and polarization change the surface tension and modify the value of the corresponding term of the activation energy. This explains their influence upon the deformation rate.

B. Gross, Brazil

1723. Vitovec, F., and Nowotny, H., On theory of dynamic deformation (in German), *Z. Phys.* **131,** 1, 41–47, 1951.

Becker's relation [*Phys. Z.* **26,** 919, 1925] between strain rate v, applied shear stress τ_a, and absolute temperature T, involves an energy Q to be supplied by thermal fluctuations in raising the shear stress in a volume V to the critical value τ_0. Becker took $Q = (\tau_0 - \tau_a)^2 V/2G$ (where G is the elastic shear modulus), and from Boltzmann's probability theorem obtained $v = C \exp[-(\tau_0 - \tau_a)^2 V/2GkT]$. The predicted forms of variation of τ_a with v and T differ in important respects from those observed in tests. Present authors point out that the agreement in form is improved by replacing $(\tau_0 - \tau_a)^2$ by $(\tau_0^2 - \tau_a^2)$. This seems reasonable to reviewer, since strain-energy increment corresponding to increase of stress from τ_a to τ_0 is proportional to $(\tau_0^2 - \tau_a^2)$, not $(\tau_0 - \tau_a)^2$.

P. S. Symonds, USA

1724. Kanzaki, H., On the plastic deformation of copper single crystals. I, II, *J. phys. Soc. Japan* **6,** 6, 454–459, Nov./Dec. 1951.

The resolved shear-stress τ, resolved shear-strain γ curve in tension had an abrupt change in $d\gamma/d\tau$ at a resolved shear strain of 0.2. Specific heat curves of crystals strained various amounts in tension had two minima on the first heating that did not appear on the second heating. These minima were assumed to correspond to a release of energy by recovery. The energy released for either minimum increased continuously with prior strain, but the temperature at which it was released increased to about 0.2 resolved shear strain and then decreased again. Author suggests that the mechanism of deformation is different above and below 0.2 resolved shear strain because of the different curvatures of the stress-strain curve and the different variation of temperature with strain on opposite sides of 0.2 resolved shear strain.

J. D. Lubahn, USA

1725. Honeycombe, R. W. K., Inhomogeneities in the plastic deformation of metal crystals I. II, *J. Inst. Metals* **80,** 45–56, 1951–1952.

I. Occurrence of x-ray asterisms: In a study of deformed single crystals of cadmium and aluminum it was found that x-ray asterisms do not always accompany plastic deformation. A hexagonal crystal, cadmium, may be extended more than 100% elongation in tension without the appearance of asterisms in x-ray Laue photographs, but when it is macroscopically bent or "kinked," asterisms occur. In a cubic crystal, aluminum, asterisms are present after less than 4% elongation in tension. Cubic metal crystals under tensile deformation, therefore, undergo more distortion as well as a greater degree of strain-hardening than hexagonal crystals. Cadmium crystals deformed in tension do

not polygonize when annealed, but those that were kinked either polygonize or recrystallize at room temperature. When the aluminum crystals were annealed at a high temperature, the asterisms became further fragmented, probably as a result of polygonization.

Author suggests that tensile deformation causes aluminum (but not cadmium) crystals to break down into a series of slightly disoriented blocks connected by regions of distortion or lattice curvature.

II. X-ray and optical micrography of aluminum: Using the techniques of x-ray and optical micrography, the structure of large aluminum crystals after a small deformation was observed. Two types of microscopic inhomogeneities are identified. The first, which occurs initially on (110) planes, is called "kink bands." These are narrow regions of curvature which separate slightly disoriented lamellae. The second is called "secondary slip bands." These occur parallel to the octahedral slip planes in the early stages of deformation, but are initially deficient in primary slip traces. Severe curvatures are generally absent but disorientation is present.

Kink bands do not occur in crystals which deform by "conjugate slip" on two or more slip planes because the stresses set up by restraints in the crystal are reduced by slip on the alternative system.

These inhomogeneities act as inhibitors of slip and play a large part in the strain-hardening of aluminum. They lead to x-ray asterisms, influence recovery, and may explain the difference between aluminum (cubic) and cadmium (hexagonal).

M. J. Manjoine, USA

1726. **Chaussin, C., Mechanical deformation of metals** (in French), *Metallurg. Constr. mécan.* **83**, 9, 665–671, Sept. 1951.

An elementary review of the basic facts and views concerning the plastic deformation of metals.

George Masing, Germany

Failure, Mechanics of Solid State

(See also Rev. 1749)

1727. **Shashin, M. Ya., Effect of cyclical overstressing and understressing on the fatigue of metals** (in Russian), *Zh. tekh. Fiz.* **21**, 10, 1184–1193, Oct. 1951.

Results of repeated bending tests with sorbitic high-alloyed steels containing Cr, Ni, Mo, and V are the following: Even if number of cycles is very great, the effect of understressing does not appear below a definite critical stress. Understressing exceeding critical stress raises endurance limit σ_E for a sufficient number of cycles. If specimen is loaded repetitively with $\sigma_i > \sigma_E$ for the number of cycles n_i, and after that with $\sigma_f > \sigma_E$ for the number of cycles n_f, there is a number n_i (called "optimal initial training") for which ratio n_f/N_f is a maximum (N_f is the number of cycles to failure at σ_f in ordinary fatigue test without preceding overstressing). For a definite "critical difference" $\sigma_f - \sigma_i$, n_f/N_f is >1. For silicon steels with high carbon content, critical difference is not observed. Author takes optimal initial training and critical difference as new criteria of sensibility of alloys to overstressing. Experimental data are explained qualitatively by a statistical theory of Afanassev.

Heinrich Mussmann, Germany

1728. **Hempel, M., Effect of the size of test bar on the fatigue strength** (in German), *Arch. Eisenhüttenw.* **22**, 11/12, 425–436, Nov./Dec. 1951.

Critical review of the literature is given, which leads to conclusion that, in most tests, geometrical influences are overshadowed by technological variables, such as residual manufacturing stresses and testing conditions.

Author's new tests show: (1) Only slight differences between fatigue strengths of small specimens (4.6 to 10-mm diam) in rotating bending and in tension-compression tests; (2) no influence of specimen size in pulsating tension and tension-compression tests of plain specimens and specimens with holes (diam 0.2 to 0.25 of specimen width); (3) appreciable effects of surface treatment and heat tratment (mechanical polishing, electropolishing, shot-peening, annealing) on residual stresses and rotating bending fatigue strength; (4) noticeable effects of testing conditions (e.g., of inertia forces not included in load indication).

It is concluded that usual stress-gradient hypothesis to explain size effects is not correct and that problem is predominantly a technological one.

F. J. Plantema, Holland

1729. **Oding, I. A., How to ascertain the cause of fatigue failures from structure and shape of the fracture surface** (in Czech, transl. from Russian), Prague, Prumysl. Vydatelstvi, 1951, 96 pp., 69 figs.

How metals break is a young science but of great importance for design, and every publication on research on the laws in this field is welcome. As most failures in machine parts are due to fatigue, this well-known author occupies himself here only with fatigue failures. He treats the laws of fatigue strength, the causes which reduce it, the shape and appearance of fatigue fractures, the change of structure in consequence of fatigue which can be ascertained by microscope and x rays. Booklet is a critical and ordered assemblage of research results, most of which are scattered in the Russian literature. It contains numerous figures and literature references and can be recommended to designers and technologists.

Pavel Kohn, Czechoslovakia

1730. **Nakazawa, H., On the correlation between stress gradient and elastic fatigue failure,** *Mem. Fac. Technol. Tokyo Metrop. Univ.* no. 1, 1–10, 1951.

Author proposes the following hypotheses for failure: "Failure occurs when the shearing strain energy of a volume element of radius ϵ at the spot of failure attains a certain constant value." His hypotheses is based on the premise that failure at any point is affected not only by the stress at that point but also by the stress at neighboring points. The radius of the volume element will take on different values depending on the kind of material, state of stress, and form of cross section. The values of ϵ determined by experiment are given by the author as follows: For elastic failure of a notched plate of mild steel due to tension, 1.4 to 1.5 mm; for elastic failure of bars of mild steel due to torsion and bending, 4 to 5 mm; and for fatigue failure of round bars of steel due to rotary bending, a value which increases from 1.08 mm as the tensile strength increases from 30 kg/mm^2.

Samuel Levy, USA

1731. **MacGregor, C. W., and Grossman, N., Dimensional effects in fracture,** *Weld. Res. Suppl.* **17**, 1, 20s–26s, Jan. 1952.

The influence of size on the transition temperature from ductile to brittle fracture was investigated by testing unnotched flat circular disks of 0.95 C steel in the M.I.T. slow testing device. Disks were simply supported around the circumference and loaded at the center. When size, including the dimensions of supports and loading members, was increased by a factor 6, the transition temperature was raised by only 8 F. Authors conclude, in this case, that size effect is of a trivial nature.

The influence of biaxiality was investigated by additional tests with unnotched rectangular plates, simply supported along two

sides and loaded by a central concentrated force. The ratio of supported to unsupported length varied from 0.5 to 2.667, by which the biaxiality ratio of the state of stress was varied from 0.483 to 0.855, i.e., from 0.483 to 1.0 when the circular disks are included in the comparison. This increase of biaxiality was found to raise the transition temperature by about 62 F.

In regard to brittle fracture strength, it was found that this quantity was raised by increasing the biaxiality ratio and decreasing the size.

Reviewer points to the fact that authors' tests are concerned only with biaxial states of stress. In actual structures, however, the brittle fracture of plates is believed to be related to the triaxiality of the state of stress at the root of the crack. In these cases, the triaxiality will be essentially related to size (e.g., plate thickness), and separation of the two effects seems impossible.

J. H. van der Veen, Holland

1732. Vivian, A. C., A new version of "strength of materials," *Metallurgia, Manchr.* **45,** 267, 29–37, Jan. 1952.

Ten years of study have led author to conclude beyond doubt that all mechanical properties are contained in three constants for each material. The three—Poisson's ratio, and k and n in "the" true stress-strain relation $\sigma = k\epsilon^n$—are said to be time- and temperature-dependent.

D. C. Drucker, USA

1733. Tarasenko, I. I., On the condition of failure of metals (in Russian), *Zh. tekh. Fiz.* **21,** 11, 1336–1344, Nov. 1951.

To combine the generalized stress-strain curves for different methods of loading, author introduces the concept of a "constant modulus of plasticity" for the equivalent state of stresses, such as yield point, ultimate tensile strength, fracture, etc., by which he means that equivalent points of all curves lie on a single ray through the origin. Then he introduces the concept of a coefficient of nonlinearity relating appropriate equivalent yield stresses for each method of loading to the yield stress of the simple tension curve, and accepts this coefficient for the plastic part of the curve as constant. In his considerations he assumes the colinearity of deviator of stress and strain vectors, and the incompressibility of the metal. Author provides some experimental data which, in the reviewer's opinion, do not supply an experimental support for his concepts.

Witold Sylwestrowicz, USA

Design Factors, Meaning of Material Tests

(See also Revs. 1698, 1699)

1734. Robinson, E. L., Effect of temperature variation on the long-time rupture strength of steels, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-33, 4 pp.

Paper presents method of computing the factor of safety of structural steel member with reference to stated life, when operating under stress at high temperature, when temperature varies moderately according to some definite pattern. Formulas presented are prepared on the supposition that expenditure of each particular fraction of the life span at elevated temperature is independent of and without influence upon expenditure of all other fractions of life to rupture. Author makes no claim that this assumption is wholly true. Suggested procedure is offered to provide means for making engineering estimates with some greater validity than always to assume worst conditions are present all the time. Desirability of taking account of certain additional influences which may differ from one material to another is recognized.

From author's summary by D. E. Hardenbergh, USA

Material Test Techniques

(See also Revs. 1686, 1720, 1721, 1748)

1735. Metzger, M., A simplified constant shear stress lever for creep tests on single crystals, *Rev. sci. Instrum.* **22,** 12, 1022–1023, Dec. 1951.

As is well known, the plastic deformation (including creep) of metallic single crystals consists of slips in certain planes and directions that depend on the crystallic system. If the metallic single crystals are a bar subjected to tensile load, the plane and direction of slipping rotate toward the bar axis. That is, if λ is the angle between the axis of the bar and the slip direction, λ decreases as the slipping progresses. At the same time, the change of λ modifies the resolved shear stress in the slip plane. Author presents an equation that expresses the tensile load necessary to maintain unchangeable the resolved shear stress. Said variable load is a function of the angle λ at the beginning of the test and of the elongation ϵ of the specimen at every moment.

The object of this work is to obtain experimentally the unchangeable resolved shear stress with the load relaxation. That was possible with a lever system based (according to author) on the one used by Andrade and Chalmers, but with the advantage that his instrument does not require the change of levers for each initial λ.

The publication presents a sketch of the instrument and several references, but more details would give a better explanation.

Simon A. Delpech, Argentina

1736. Scarlett, J. A., and Robertson, J. A., An automatic apparatus for testing refractories under tensile and compressive loads at high temperatures, *J. Amer. ceram. Soc.* **34,** 11, 348–353, Nov. 1951.

Paper gives details of design and operation of an apparatus for load tests on refractories up to 220 C. Deformation and temperature are controlled and recorded automatically, and either tension or compression loads can be applied. Heating is in a graphite-resistor furnace. Specimens are much smaller than those for the standard ASTM load test.

W. H. Duckworth, USA

1737. Cooper, W. E., Determination of principal plastic strains, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-128, 9 pp., 2 figs., 2 tables.

The measurement of finite strains forms an important experimental item in the field of plasticity. One of the strain-indicating devices for this purpose is the photogrid, which is a device consisting of a grid applied photographically to the surface of the specimen. The method presented here is to determine the principal plastic strains from photogrid data, when the grid is not necessarily in alignment with the principal strain directions. The accuracy of the method depends on the ability of measuring accurately the grid spacing. Beginning with strain definition in tensor notation, author passes on to determination of displacements, determinations of magnitude and direction of principal strains, and illustration of the method by an example on the evaluation of the complex strains in the tensile specimen of 2S-O aluminum alloy with a grid orientation of 51°. The method has a direct application in the problem of forming of sheet material when the directions of the principal strains cannot be predicted.

S. K. Ghaswala, India

1738. Rowe, R. G., Testing abrasive wheels with the sonic comparator, *Nondestructive Testing* **10,** 2, 29–34, Fall 1951.

Based upon the premise that two identical bodies will have the same frequency of vibration, an acoustical method for testing

abrasive wheels is described. The wheel is supported at the nodes of a main node of vibration, being in contact with an electromagnetic transducer near an antinode of vibration. Transducer is fed by a variable frequency generator which is connected with the horizontal plates of an oscillograph. The vertical plates are supplied by a microphone positioned near an antinode. When the wheel is not sound, the normally pure tone of the ringing wheel is distorted, so that flaws can be detected. A typical plot of impact penetration vs. sonic frequency is given, showing that the method is useful in comparing the grade characteristics of any group of abrasive wheels manufactured by the same process.

O. Ruediger, Germany

Mechanical Properties of Specific Materials

(See also Revs. 1683, 1710, 1715, 1717, 1724, 1725, 1732, 1735, 1885)

1739. Freyssinet, E., The deformation of concrete, *Mag. Concr. Res.* no. 8, 49–56, Dec. 1951.

This paper by one of the outstanding authorities on concrete technology, and in fact the pioneer of prestressed concrete, sets a new pace in a deeper understanding of the laws of deformation of concrete. Examples show the wide disparity in the actual and theoretical results obtained on concrete slabs prestressed in two directions. Tests indicate that such slabs carry as much as four to five times the load predicted by classical computations, without the formation of any cracks. These results were obtained on slabs of prestressed runways at Orly, and for the floors of the Gare Maritime at Le Havre.

In order to explain such discrepancies, author develops a theory based on the constitution of concrete, presuming it to be a complex "solid-liquid," to which the laws of thermodynamics may be applied, and not just a solid substance as assumed in ordinary analysis. Concrete is a mixture of inert aggregates for which Young's modulus varies from 7×10^5 to 9×10^5 kg per sq cm for good qualities, cement in the form of a fine powder, and water. The cement dissolves slightly in water, depending on its chemical nature, i.e., saline ions are dispersed at random in the liquid. Where they gather in sufficient numbers at points where the solution is very rich, they will combine with molecules of water to form relatively stable structures, since they correspond to minimum values of the attraction potential and to a reduction in the volume of water and cement. These are the hydrate crystals. The surface energy of this assembly of crystals tends toward a minimum, which means that the large crystals are less soluble and tend to absorb the smaller, or prevent their formation by diminishing the concentration of the solution. On the other hand, a crystal can grow only by the movement of ions, which must reach the crystal surface by movement through the liquid along canals which become narrower and more sinuous as the number of crystals grows. Thus, before associating themselves with a pre-existent crystal, the ions have plenty of chance to group into new crystals if they meet a zone where their concentration becomes sufficient. The average size of the crystals will thus be smaller as the circulation of the ions in the mass is slower and more difficult.

The above hypothesis led the author to important conclusions, and firmly established the concept of ionic structure of concrete and its role in various scientific and industrial applications. It is shown very aptly that concrete has qualities similar to living tissues, the most interesting and useful being its property of autogenous healing of cracks, and its ability to overcome causes of failure. The principles of Laplace, Kelvin, and Carnot are then used to demonstrate mathematically the underlying principles so formulated by bringing the characteristic of shrinkage of concrete into a simple expressible algebraic law. References are also made to creep and elastic and plastic deformation, with brief mention of shear strains. It has been verified experimentally by author that there is no discontinuity in the stress-strain curve of concrete in changing from compression to tension. The zone requiring fuller exploration is not this one but the region of the limit of elastic and plastic tensile strains. In this zone, the water-hydrate equilibrium causes complex phenomena of breakdown and reconstruction, the role of which is very important from the point of view of the behavior of prestressed concrete in statically indeterminate structures. Whatever are the considered opinions of other authorities (such as Professor Mesnager's concept of concrete), and whether the author's present hypothesis is fully accepted or not by future experimentalists, the paper forms a notable piece of literature in the growing field of prestressed concrete and deserves to be thoughtfully digested because of its logical approach and verification of data.

S. K. Ghaswala, India

1740. Fukada, E., The vibrational properties of wood. II, *J. phys. Soc. Japan* **6**, 6, 417–421, Nov./Dec. 1951.

Supplementary to the information presented in part I of this paper [AMR **4**, Rev. 4173], influences are described of moisture content and temperature of certain softwoods and hardwoods on their logarithmic decrements λ.

With decrease in moisture content of wood, its internal friction increases and the peak in $\tan\delta$-frequency curve shifts to a lower frequency, where $\tan\delta$ is the delayed phase angle between stress and strain; i.e., $\tan\delta = \lambda/\pi$. With an increase in temperature at 0% moisture content, Young's modulus and $\tan\delta$ decrease and the peak in $\tan\delta$ shifts to a higher frequency.

The experimental activation energy, which is larger for hardwoods than for softwoods, amounts to approximately 1000 cal/mol.

The frequency characteristics of $\tan\delta$ can be explained by superimposing both Eyring's and Newton's viscosity.

E. G. Stern, USA

1741. George, W., The measurement and physical interpretation of the mechanical strength of filaments, *Text. Res. J.* **21**, 12, 847–861, Dec. 1951.

Paper contains an approach to explain filament-strength problems by the existence of microdomains. The mathematical relation between the strength distribution of $f(x)$ of one domain and the strength distribution $g(n)$ of a specimen of length n is given. From the experimental data on size effects, it is at first concluded that the domains are numerous or small in size.

Author shows that dimensions deduced from studies on x-ray line broadness as a function of plastic strain seem to correlate with strength properties. Conceptual pictures of the fine structure of solids, metals, and plastics are presented.

An apparatus giving a constant time-strain-rate fiber deformation is described. The obtained data, exhibiting the known strong dependence of strain rate on strength, suggest that changes in domain size are related to diffusion effects.

The known effects of relative humidity on fiber strength properties are then discussed in the light of these ideas.

D. De Meulemeester, Belgium

1742. Picard, H. C., The irregularity of slivers, *J. Text. Inst. Trans.* **42**, 12, T503–T509, Dec. 1951.

Author has developed an index of irregularity for fibrous strains such as yarns and slivers. Present use of coefficient of variation does not indicate to what degree a strand approaches

the ideal, i.e., perfect randomness. Author defines true index of irregularity as ratio of coefficient of variation of actual material to coefficient of variation of theoretically perfectly random material. Random coefficient depends upon fiber weight per unit length distribution, fiber length distribution, and number of fibers to be expected in a cross section of the strand.

Author then derives a general expression for the mean and coefficient of variation as defined by the Poisson distribution in terms of parameters derived from the above three. He then obtains special formulas from this general one to express certain common conditions, such as Case (1) fibers have same weight per unit length; Case (2) fibers are solid cylinders of constant cross section and vary only in length; Case (3) fibers are solid cylinders and vary in length and weight per unit length; Case (4) fibers in which both length and weight per unit length vary but are correlated.

Not all of these cases have been studied experimentally. In Case (4), author found that all actual values of coefficient of variation were greater than the theoretical value. Thus, use of his true index provides a means for comparing widely varying types of fibers and strands made from them.

Rogers B. Finch, USA

1743. Leonard, W. J., Investigation of materials developed for adaptability to wax model production, *David W. Taylor Mod. Basin Rep.* **784,** 7 pp., Oct. 1951.

1744. Faris, F. E., Green, L., Jr., and Smith, C. A., The thermal dependence of the elastic moduli of polycrystalline graphite, *J. appl. Phys.* **23,** 1, 89–95, Jan. 1952.

Young's modulus and the shear modulus of grade SA-25 molded graphite and grade AUF extruded graphite were measured as functions of temperature in the range from 25 C to 2000 C. For the extruded material, variations of the two moduli with position and direction relative to the axis of extrusion were also investigated. The moduli were found to increase with temperature, a behavior in contrast with that exhibited by most materials. Maxima in the low-frequency shear modulus values, and increases in the internal friction of both graphites observed in the range from 1550–1750 C may possibly be interpreted in terms of grain-boundary relaxation. The bulk modulus and Poisson's ratio at room temperature were calculated from the data for the nominally isotropic SA-25 graphite to be 6×10^{10} dynes/cm^2 and 0.27, respectively.

From authors' summary

1745. Davis, E., and Temple, S. G., Batch and continuous annealing of copper and copper alloys, *J. Inst. Metals* **80,** 287–296, 1951–52.

The more exacting quality requirements in respect, for example, of uniformity of crystal structure and properties and surface finish, and the need for improving operating efficiency and output, have resulted in recent years in considerable changes in annealing equipment and practices in the production of wrought copper and copper alloys. Some of these are outlined, and, since they involve a knowledge and application of fundamental considerations, the annealing characteristics of representative copper-base alloys are discussed, and reference is made to the effect of impurities on the softening of copper alloys and to heat-treatment other than annealing to produce soft material, such as stress-relief annealing, solution heat-treatment, and tempering.

Various types of batch and continuous furnaces are described, and the factors influencing uniformity of annealing and the relative merits, limitations, and applications of both types of annealing are briefly considered. Since copper and copper alloys readily oxidize when annealed in air, the development of protective atmospheres has progressed rapidly, and the conditions to be fulfilled in bright annealing are detailed. Particular reference is made to copper-zinc alloys which not only oxidize readily but from which zinc may volatilize, to the detriment of the surface appearance.

From authors' summary

1746. Gerard, P., and Troussart, L., Tempering of plate glass (in French), *Rev. univ. Min.* **7,** 11, 396–409, Nov. 1951.

The state of stress in tempered plate glass is explained and calculated on the basis of temperature gradient and the change in the coefficient of thermal expansion α with change in temperature T. The latter effect was not considered in the earlier work of Adams and Williamson. Experimental curves of α vs. T are shown. The relaxation of stress with time is calculated, using Maxwell's law and an empirical law of variation of viscosity with temperature.

Edward Saibel, USA

1747. Gerard, P., and Troussart, L., New method for measurement of the viscosity of glass in the transition zone (in French), *Rev. univ. Min.* (9) **7,** 11, 393–396, Nov. 1951.

Instead of the usual method of using the rate of elongation of a weighted glass fiber in a furnace for the determination of viscosity, authors have used the rate of compression of a glass rod loaded as a column and measured with a Chevenard differential dilatometer. Advantages claimed are: The short rod used is entirely in the hot zone of furnace, actual and effective lengths are the same; the temperature of the furnace is determined from the differential expansion of two elements of the dilatometer. Data for a soda-lime glass show consistent results within viscosity range of 10^{10} and 10^{15} poises.

E. B. Shand, USA

1748. McGraw, D. A., A method for determining Young's modulus of glass at elevated temperatures, *J. Amer. ceram. Soc.* **35,** 1, 22–27, Jan. 1952.

Because of the experimental difficulties imposed by the prominence of delayed elastic and viscous effects, little investigation has been made of the instantaneous elastic modulus of soda-lime-silica glasses above approximately 500 C. The method described provides a means of measuring Young's modulus of such glasses. The method is applicable from room temperature to 680–700 C. The sample, a cylinder of glass encased in a thin-walled metal tube, is mounted vertically in a furnace and bent as a cantilever beam by horizontal application of load at the top of the sample. The instantaneous deflection of the composite rod is measured and recorded by a suitable extensometer and oscillograph circuit. Young's modulus is calculated from the difference between the load-deflection characteristics of the composite sample and those of an empty tube of the same metal. Data are presented for three soda-lime-silica glasses in the range 25 to 700 C.

From author's summary

1749. Pugh, E. M., Heine-Geldern, R. v., Foner, S., and Mutschler, E. G., Glass cracking caused by high explosives, *J. appl. Phys.* **23,** 1, 48–53, Jan. 1952.

The velocity of shock waves in glass increases with increasing shock intensity. The highest observed shock velocity is 6150 m/sec, which exceeds the velocity of sound by at least 10%.

"Secondary fracture" of glass, first observed by Schardin and Struth, is produced very readily by detonation of a high explosive in contact with the sample. For sufficiently intense disturbances, this secondary fracture is initiated at the velocity of propagation of the disturbance. The time delay between passage of the disturbance and the first appearance of cracks decreases with increasing shock intensity.

From authors' summary

1750. **Christiansen, V., Corrosion problems with aluminum and its alloys** (in Swedish), *IngenVetenskAkad. Tidsk. Tekn. Forsk.* 22, 4, 103–113, 1951.

A brief report on how aluminum and its alloys are affected by corrosion. It deals with the oxide layer formed on the aluminum surface and its effects, the influence on corrosion resistance of compounds and alloy additions, the influence of heat treatment, various forms of corrosion, and how aluminum is affected by attacks of various kinds of atmosphere, different waters, and some chemicals. From author's summary

1751. **Brennert, S., Different kinds of corrosion attacks** (in Swedish), *IngenVetenskAkad. Tidsk. Tekn. Forsk.* 22, 4, 98–103, 1951.

A report on the attacks most common in practice, comprising general corrosion, pitting, intergranular corrosion, stress corrosion and "selective" corrosion (de-zincification). Special stress is laid on the fact that, where pittings occur, these are generally not attributable to defects in the material.

From author's summary

1752. **Fast, J. D., Ageing phenomena in iron and steel after rapid cooling,** *Philips tech. Rev.* 13, 6, 165–171, Dec. 1951.

Aging after quenching of iron or steel is attributed to the presence of small quantities of carbon, nitrogen, or oxygen in the alpha iron. The influence of manganese with carbon or nitrogen has also been studied. Results indicate that oxygen causes virtually no quench aging. Carbon and nitrogen are slightly soluble in alpha iron and both cause considerable aging. Manganese suppresses the aging of iron containing nitrogen but not that of iron containing carbon. An explanation is proposed by assuming that the nitrogen atoms in the lattices will preferably occur in the vicinity of manganese atoms where they are bound more strongly than when surrounded by iron atoms. Thus the formation of iron-nitride precipitates takes place at a perceptible rate only at high temperatures. T. J. Dolan, USA

1753. **van der Beck, R. R., and Everhart, J. O., Firing and cooling shrinkage behavior of structural clay bodies,** *J. Amer. ceram. Soc.* 34, 12, 361–365, Dec. 1951.

Length-change determinations on 19 sewer-pipe bodies were used to study the shrinkage of structural clays. Determinations over both heating and cooling cycles were included. Many of these materials are used in the production of other structural clay products and they represent mixes of shales and clays commonly used throughout the industry. The data consequently are of interest to all producers of structural clay products. A description of the techniques employed in securing the data, as well as a discussion and interpretation of the results, are given. Particular emphasis is placed on the possibility of conserving fuel and firing time, as well as reducing rejects, by applying information obtained. It was found that nearly all the shrinkage occurs in a very small portion of the total firing cycle, and that there are periods of slight volume change where considerations of shrinkage are of small consequence in firing. From authors' summary

Mechanics of Forming and Cutting

(See also Rev. 1713)

1754. **Kelley, S. G., Jr., Hard, brittle materials machined using ultrasonic vibrations,** *Mater. Methods* 34, 3, 92–94, Sept. 1951.

Hard ceramic and metallic parts, such as sintered aluminum oxide and tungsten carbide, are machined by a soft steel tool vibrating at 27,000 cps applying fine abrasive particles at the same time. A hole 1/4 sq in. in area can be made in 18 min through a piece of sintered tungsten carbide 0.125 in. thick. No heat occurs to change the structure of the workpiece. Process is usable for making a hole in diamond and can be applied for forming of threads in carbide nuts, drilling jewel bearing, shaping of drawing and piercing dies made of hardened chromium steel. Alnico parts can also be worked. A. O. Schmidt, USA

1755. **Schemmer, K., On the determination of intermediate dimensions in drawing on multiple drawing machines** (in German), *Arch. Eisenhüttenw.* 22, 11/12, 367–370, Nov./Dec. 1951.

A graphical method and a special slide rule are described.

C. Zwikker, Holland

Hydraulics; Cavitation; Transport

(See also Revs. 1717, 1907)

1756. **Blair, J. S., New formulae for water flow in pipes,** *Instn. mech. Engrs. Proc.* 165 (W.E.P. 64), 74–87, 1951.

Existing formulas for flow velocity in pipes are stated to be either too limited in scope or too general to give sufficient accuracy in practical application. On basis of a review of previous formulas and data, author proposes four new empirical formulas of the type $V = cm^a i^b$ for pipes in new condition using water at normal temperatures. Here V is the mean velocity, m the hydraulic radius, i the hydraulic gradient, and c, a, and b are constants for which four sets of values are given, depending only upon the material of the internal surface of the pipe. A maximum error of $\pm 10\%$ is claimed for these formulas.

Louis Landweber, USA

1757. **Jansen, R. B., Surface curves for steady nonuniform flow,** *Proc. Amer. Soc. civ. Engrs.* 77, Separate no. 96, 7 pp., Nov. 1951.

Paper puts the usual equation for gradually varied flow into a form which is integrated numerically for the case of a trapezoidal channel. The results are not tabulated in the article but are available (for a limited number of channel shapes) by purchase from the author. Dwight F. Gunder, USA

1758. **Binnie, A. M., and Thackrah, D. G., Water hammer in a pumping main and its prevention,** *Instn. mech. Engrs. Proc.* 165 (W.E.P. 64), 43–52, 1951.

In continuing an earlier investigation, occurrence and prevention of water hammer in pumping mains were studied theoretically and in laboratory. Automatic air-inlet valves near pump and relief valves were compared with unprotected pipe. Air cushion was found effective, whereas relief valve was found ineffective in reducing violent pressure rises. Calculated results corresponded closely with measured values. John S. McNown, USA

1759. **Jupillat, R., and Trividic, A., On the evolution of water hammer in an intake tunnel upstream from a surge tank** (in French), *Houille blanche* 6, no. B, 640–646, Oct. 1951.

Paper presents an analysis of water-hammer phenomenon due to closing in the forced conduit, at the distributor, under the surge tank, and in the intake tunnel upstream from the surge tank. The graphical method of Bergeron is used to study the presented cases of water hammer. In the cases studied, the closing time of the turbine distributors and the dimensions of the structures are very different from those generally adopted in practice. This apparently was done to make the mechanism of the phenomena studied more pronounced. A review of the ideas,

with reference to water hammer, concerning reflection and refraction of a wave at a junction is also presented.

Reviewer believes this paper will be of interest in the hydroelectric field, as it analyzes the phenomena taking place upstream of the surge tank. Also, comments in the discussion section should interest engineers in the fluid-transmission field.

Charles Newman, USA

1760. Noltingk, B. E., and Neppiras, E. A., Cavitation produced by ultrasonics, *Proc. phys. Soc. Lond.* (*B*) **63,** part 9, 369B, 674–685, Sept. 1950.

The differential equation for bubble growth is derived using the assumptions: (1) Pre-existence of bubble nuclei; (2) constant quantity of gas in the bubble; (3) isothermal expansion of gas; (4) incompressible liquid; (5) surface tension constant; (6) sinusoidal pressure variation; (7) bubble diameter small compared to a wave length; (8) neglect of vapor pressure within the bubble.

The differential equation is solved by means of a differential analyzer for a wide range of pressure amplitudes, frequencies, and bubble nuclei sizes. It is predicted that cavitation will disappear above a certain frequency. The equation for the pressures resulting from adiabatically collapsing gas-filled spherical bubbles is derived. No experimental data are given. The theory is extended in a further paper (see following review).

George H. Sines, USA

1761. Neppiras, E. A., and Noltingk, B. E., Cavitation produced by ultrasonics: Theoretical conditions for the onset of cavitation, *Proc. phys. Soc. Lond.* (*B*) **64,** part 12, 384B, 1032–1038, Dec. 1951.

A theoretical extension of a previous paper (see preceding review) in which equations were developed describing the motion of a gas-filled cavitation bubble subjected to alternating pressure. The theory is now extended to show that cavitation is restricted to a definite range of the parameters (a) alternating pressure amplitude, (b) frequency of the applied pressure, (c) radius of bubble nucleus, (d) hydrostatic pressure. It is shown that under certain conditions there is a sharply defined threshold for the onset of cavitation. In this treatment it was necessary to assume the pre-existence of bubble nuclei above a certain minimum size as a condition for bubble growth. Solutions of some equations were made with the aid of a differential analyzer. No experimental data are presented.

George H. Sines, USA

1762. Shal'nev, K. K., Cavitation due to roughnesses of a surface and the resultant erosion (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **78,** 1, 33–36, May 1951.

Author reports on experiments on cavitation behind unevennesses in the form of a triangle, segment, or step with heights from 0.012 to 0.24 in. in small channels and gaps [see AMR **4,** Rev. 4189]. Cavities originate on vortex axis behind unevenness at time intervals between 114 and 369 $\times$ 10^5 second, as in separating flow cavitation behind smooth bodies. In gaps, danger of erosion depends on the relative height of unevenness in regard to thickness and velocity distribution of the boundary layer. In the beginning phase, the Strouhal number remains nearly constant (0.23) for greater heights and falls off with them. Erosion becomes very pronounced if unevennesses protrude through boundary layer into free stream.

Anton Kuhelj, Yugoslavia

1763. Rohsenow, W. M., Fink, C. H., and Pollis, S. R., Flow through two orifices in series, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-87, 4 pp., 12 figs.

Principal conclusions of this experimental investigation are: (1) A pressure rise through the second orifice occurs when the axial spacing between the two orifices is less than about two pipe diameters and the orifice diameters are approximately the same. (2) The discharge coefficient of the upstream orifice is substantially independent of the downstream orifice size and location, and of Reynolds number in the range investigated (10^4 to 10^5, based on the upstream orifice diameter). (3) A double orifice can be devised to have the same available measuring head as a single orifice, but with a smaller pressure loss. Standard coefficients for vena contracta taps can be used for the upstream orifice as a first approximation.

From authors' summary by Alb. Schlag, Belgium

1764. Ghetti, A., Experimental investigation of the stability of governing of hydroelectric groups with pressure conduit and surge tank (in Italian), *Energia elett.* **28,** 11, 619–639, Nov. 1951.

Reported experiments were conducted upon an actual hydroelectric plant with a pressure conduit-surge tank system failing to satisfy Thoma's condition of stability. Object of researches was to investigate stabilizing action of group governor on conduit-tank system, and check Evangelisti's theoretical approach taking account of such action.

Reported results give good confirmation of theory, and show that stability of conduit-tank system may be largely controlled by group governor.

Giuseppe Evangelisti, Italy

1765. Escande, L., Theoretical study of the stability of surge tanks with throttling (in French), *C. R. Acad. Sci. Paris* **234,** 3, 299–301, Jan. 1952.

Author studies the stability of surges in a surge tank with restricted orifices. He assumes the surge tank (without restriction) does not satisfy the condition of stability of Thoma. (Condition: $2p_0h_0 < 1$ in relative values.) He then proves that, when the restricted orifices are sufficiently small, stability will nevertheless be obtained. He gives a limiting value for the restricted orifices and calculates the maximum amplitude of the surges.

Charles Jaeger, England

1766. Rouse, H., Howe, J. W., and Metzler, D. E., Experimental investigation of fire monitors and nozzles, *Proc. Amer. Soc. civ. Engrs.* **77,** Separate no. 92, 29 pp., Oct. 1951.

Fire streams from standard nozzles are poor counterparts of the ideal jet with parabolic trajectory. Jet breakup and dispersal have been attributed to air drag, but authors reason and prove experimentally that the actual cause is the initial flow turbulence. This is reduced with good hydrodynamic design. Monitor passages are made long and large in section with constant or gradually increasing area, and section changes are well rounded with direction changes containing guide vanes. Nozzle is made with a well-rounded base, a relatively rapid convergence, and an unconfined zone of jet contraction. Any possibility of the gasket at the nozzle base projecting into the flow is eliminated.

Experiments consisted in calibrations and studies of the discharging jet near the nozzle, in gallery studies of jet concentrations at a distance of 90 ft, and in open-air trajectory studies made photographically and with a transit. The best nozzle design was achieved by keeping it relatively short to minimize boundary-layer growth in the high-velocity region, but with enough contraction angle (60° total) that the base may be properly rounded to reduce eddy formation. Jet-velocity traverses revealed reduced boundary-layer thickness, and gallery tests showed improved concentration of the jets with such designs. Redesigned monitors gave a 3 to 7% increase in discharge coefficient, and high-speed photographs of the jets as well as gallery-concentration measurements showed considerable reduc-

tion in spread. At 200-ft range, the redesigned monitor showed an improvement of 26% in the proportion of water striking a vertical 10-ft square target while the maximum range was 20% better.

Performance test results are summarized for the recommended monitors and nozzles at pressures of 50 to 200 psi, inclination angles of 20° to 50°, and for jet diameters of $1^1/_2$ to 3 in. The horizontal throw was maximum for the 30° angle and for a pressure of about 150 psi. Paper is noteworthy in showing how application of good flow-design principles can improve an apparatus which for sixty years has been regarded as so nearly perfect as to permit no further improvement.

J. M. Robertson, USA

1767. **Yamaguchi, S., On the effect of the radius and concentration of a drop of solution on the surface tension and saturated vapor pressure** (in Japanese), *J. meteor. Soc. Japan* **29**, 11, 384–388, Nov. 1951.

Author evaluates the effect of the radius and concentration of a drop of solution upon the surface tension, and applies the result to the evaluation of the drop of NaCl solution. He shows that the vapor pressure exerted by the concentrated solution of NaCl-nucleus whose size is $10^{-15}g \sim 10^{-17}g$ is very different from that of present common knowledge.

From author's summary

1768. **Tawde, N. R., and Parvatikar, K. G., Performance of sessile drop in surface tension measurements,** *Indian J. Phys.* **25**, 10, 473–480, Oct. 1951.

The accuracy of surface-tension measurement by the sessile drop method is improved by means of a theoretical relation developed between h/r and a^2/r^2. Tables are given based on the Bashford and Adams solutions (1883) of the fundamental capillary equations and those of the sessile drop. An improved experimental method is described and new data are presented. Reviewer believes method to be as accurate as any available. For example, the surface tension of water at 20 C is determined to be 72.62 ± 0.05 dynes per cm as compared with 72.75 ± 0.02 dynes per cm given in the International Critical Tables.

Bruce R. Mead, USA

1769. **Butov, A. M., Priss, L. S., and Shvidkovskiĭ, E. G., Viscosity of alloys: lead-tin** (in Russian), *Zh. tekh. Fiz.* **21**, 11, 1319–1324, Nov. 1951.

By measuring the decrement of torsional oscillations of a cylindrical beaker filled with liquid metal, authors derive the kinematic viscosity of pure Pb and Sn and of alloys (20%, 35%, 60% Pb) at eight temperatures between 250 and 610 C. Present paper contains no experimental details and no complete presentation of the theory of measurement (reader is referred to previous work), but there is a supplement to the theory providing a relatively simple numerical evaluation of the experimental data. Results are given to 3 figures. Reviewer notes that results for pure metals tie up reasonably well with the work of other authors, and that, so far, there is little knowledge of the viscosity of alloys.

R. Eisenschitz, England

1770. **Johnston, H. L., Mattox, R. W., and Powers, R. W. Viscosities of air and nitrogen at low pressures,** *NACA TN* 2546, 22 pp., Nov. 1951.

Slip coefficients and viscosity values obtained by oscillating-disk viscosimeter [*J. phys. Chem.* **44**, 9, 1038–1058, Dec. 1940] are presented at 306–273 K at pressures from 500 to 0.0005 mm Hg, and at 194–79 K at pressures from 500 to 0.3 mm Hg. Linear dependence of slip coefficient on inverse pressure is found above, and the free-molecule viscosity law below 0.02 mm Hg. Slip coefficient shows linear dependence on mean free path ($0 < L < 0.5$ mm) except for slight deviations which, due to the scarcity of experimental results, do not allow conclusions.

V. G. Szebehely, USA

1771. **Swindells, J. F., Coe, J. R., Jr., and Godfrey, T. B., Absolute viscosity of water at 20° C,** *J. Res. nat. Bur. Stands.* **48**, 1, 1–31, Jan. 1952.

The determination was made by the method of capillary flow. By means of a calibrated injector, various known constant rates of flow were produced in capillaries of measured dimensions, and observations were made of the corresponding pressure drops through the capillaries. The effects of the ends of the capillaries were rendered negligible by the simultaneous treatment of data obtained with pairs of capillaries having essentially the same diameters but different lengths.

The value found for the viscosity of water is 0.010019 poise as compared with 0.01005 poise, which has generally been accepted for the past 30 years. The estimated accuracy of the new determination is ±0.000003 poise. From authors' summary

1772. **Bailey, J. F., Metastable flow of saturated water,** *Trans. ASME* **73**, 8, 1109–1116, Nov. 1951.

Based on the assumption that, for discharge pressure appreciably below the saturation pressure, the fluid flowing in a nozzle or tube consists of a metastable liquid core surrounded by an annular ring of saturated vapor, a coefficient of contraction of the liquid core due to evaporation is obtained and is used to modify the ordinary mass-flow equation. This area-contraction coefficient is dependent upon the amount of vapor formed along the flow path, and is evaluated with an average value of a coefficient of evaporation obtained in seven short-tube tests.

The incorporation of this contraction coefficient in the mass-flow equation gives mass-flow values within 10% of measured values of several nozzles investigated by the author and previously by Danforth, all under adiabatic flow conditions.

C. H. Wu, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 1762, 1904)

1773. **Byushgens, S. S., On streamlines** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **78**, 5, 837–840, June 1951.

Author continues his earlier work [*Izv. Akad. Nauk. SSSR Ser. Mat.* **10**, 73–96, 1946; also AMR **3**, Rev. 512]. In the notation of this article (with J instead of I), $\delta = \omega_0^1\omega_0^2\omega_0^3 \neq 0$, $p = p_\alpha\omega_0^\alpha$, $q = q_\alpha\omega_0^\alpha$, $r = r_\alpha\omega_0^\alpha$, he defines the field of vectors "adjoint" to the field J_3:

$$J = \frac{dJ_3}{ds} - (\text{div } J_3)J_3 = q_3J_1 - p_3J_2 + (p_2 - q_1)J_3$$

When J is normal to a family of surfaces, J_3 is called semispecial; when J is a gradient, J_3 is called special. It is proved (a) that the congruence of streamlines is semispecial, and (b) that $(d \ln V)\omega_0^1\omega_0^2 = (p_2 - q_1)\delta$; these two conditions are necessary and sufficient for streamlines. It is also shown that a congruence of parallel helices on parallel cylinders is semispecial and minimal.

Courtesy of Mathematical Reviews D. J. Struik, USA

1774. **Lahaye, E., Contribution to the solution of the equations of motion of a fluid and of the equations of the general atmospheric circulation** (in French), *Inst. roy. météor. Belgique Mémoires* **38**, 79 pp., 1950.

In part I, chap. I, the author claims to obtain a new method

of expressing the velocity **v** in a region in terms of the vorticity **w**, and thence of obtaining a steady general solution of Euler's equations for perfect inviscid fluids in which the velocity vector takes on an assigned steady tangential value at each point of an arbitrary closed surface S. From this he claims to show that it is necessary that $\mathbf{w} = k\mathbf{v}$, k = const, and that the strong Bernoulli theorem must hold. Hence he obtains an integral equation for the velocity and claims to prove the existence of a solution. In chap. II, he claims to extend the result to isentropic perfect gas flows. In chap. IV, he claims to obtain a similar integral equation for flow of a viscous incompressible fluid. Part II treats unsteady motions, and part IV, relative motions.

[Reviewer's note: The results given are important if they are true. The reviewer makes no pretense of having followed in detail the lengthy and elaborate analysis, but he finds even the opening steps quite incomprehensible. The author assumes that S can be written in the form $z = \nu(x, y)$, and in all his "solutions" he uses partial integrals from $\nu(x, y)$ to z, stating that on the surface they vanish. Such integrals are certainly meaningless for any surface S which is not convex, and they are dubious in any case. The author does not state at the outset whether he is considering the exterior or interior problem; for the former, such integrals cannot possibly vanish on all of S. He applies also a mysterious surface condition for which he gives three different forms (eq. (2.8), footnote p. 11, and eq. (3.2)). These do not seem to be equivalent. One of them is $\mathbf{w}\cdot d\mathbf{S} = 0$. By Stokes's theorem it follows then that $\mathbf{v} = 0$ on S, so that the boundary velocity is by no means arbitrary. In any case, it seems most unlikely that the velocity in an inviscid fluid can take on either arbitrary or zero values on a given closed surface. Finally, if we grant all the author's analysis up to p. 11, it does not at all follow that $\mathbf{w} = k\mathbf{v}$ is necessary, but merely that it is sufficient to satisfy some of his conditions. It is a well-known theorem due to Gromeka ["Nekotorfe sluchai dviziheniya neszhimaemoĭ zhidkosti," Kazan, 1881, see Gl. II, §9a] and Beltrami ["Opere matematiche," vol. 4, Hoepli, Milan, 1920, pp. 300–309] that if $\mathbf{w} = k\mathbf{v}$, then independently of whether or not k = const, the strong Bernoulli theorem holds.] C. Truesdell, USA

1775. Lahaye, E., General property of a vortex in a steady motion of a perfect fluid (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **36**, 911–931, 1950.

The author claims to obtain again the results of part I, chap. II in previous paper (see preceding review). Now he distinguishes two cases: S is not a cylinder, or it is. For the latter case he claims that, in general, the motion must be irrotational. The analysis is based on formulas taken from the above reviewed paper, and the results are open to the same objections.

C. Truesdell, USA

1776. Gerber, R., On the existence of irrotational, plane, periodic flows of an incompressible heavy liquid (in French), *C. R. Acad. Sci. Paris* **233**, 21, 1261–1263, Nov. 1951.

1777. Janour, Z., Resistance of a plate in parallel flow at low Reynolds numbers, *NACA TM* 1316, 40 pp., Nov. 1951.

Paper reports careful measurements made in oil channel at Göttingen to find lower Reynolds number limit of Blasius plate-drag law. For Reynolds numbers between 10 and 1000, resistance coefficient was found to be given by: $C_D = 2.90\ Re^{-0.60}$ with a mean error $\pm 3\%$.

For $Re > 10^3$, resistance approaches Blasius form. Extrapolation of author's curve shows final agreement at $Re \sim 2\ (10^4)$. Edge resistance for plates of finite width was found by varying depth of immersion of experimental plate in oil stream. For Reynolds number range 30 to 2300, edge resistance is given by $W = 1.6\mu l v$ with a mean error $\pm 6\%$. Here l is length of edge in flow direction, μ fluid viscosity, v stream velocity. Aaron Shaffer, USA

1778. Stanitz, J. D., Design of two-dimensional channels with prescribed velocity distributions along the channel walls. I—Relaxation solutions, *NACA TN* 2593, 69 pp., Jan. 1952.

A general method is developed for the determination of the shape of two-dimensional unbranched channels having prescribed flow velocities along the walls. The flow is assumed to be inviscid and irrotational, and either incompressible or compressible. Two types of compressible flow are considered: The general type with $\gamma = 1.4$, for example, and the simplified type with $\gamma = -1$. A number of examples are shown and the shapes obtained with the various types of flows are compared.

John R. Spreiter, USA

1779. Stanitz, J. D., Design of two-dimensional channels with prescribed velocity distributions along the channel walls. II—Solution by Green's function, *NACA TN* 2595, 35 pp., Jan. 1952.

A method, based on Green's function, is developed for the determination of the shape of two-dimensional unbranched channels having prescribed flow velocities along the walls. The flow is assumed to be inviscid and irrotational and either incompressible or compressible, with $\gamma = -1$. The final solution is attained through a numerical procedure. The time required for solution is considerably less than with the relaxation method presented previously by author (see preceding review).

John R. Spreiter, USA

1780. Lord, W. T., Free-streamline jets in shear flow, *Proc. Camb. phil. Soc.* **48**, part 1, 197–201, Jan. 1952.

Briefly describes solutions for free-streamline jets issuing from a gap in a flat plate when vorticity is constant.

M. J. Goglia, USA

1781. Szablewski, W., Contributions to the theory of the spreading of a free jet issuing from a nozzle, *NACA TM* 1311, 72 pp., Nov. 1951.

Translation from *Untersuchungen u. Mitteilungen* no. 8003, 1944.

1782. Hopwood, F. L., Water bells, *Proc. phys. Soc. Lond.* (*B*) **65**, part 1, 385B, 2–5, Jan. 1952.

Author shows that when water is discharged through an annular slit above a plane water surface, the sealed "water bells" thus formed exhibit some novel and remarkable properties not hitherto described. The primitive water bell is a dome-shaped bubble whose dimensions increase with increased rates of flow. If this is perforated with a finger the maximum diameter of the bell suddenly doubles itself. On continuously reducing the flow, the expanded bubble contracts and assumes an alternating sequence of stable and semistable forms of great beauty. All these, when perforated, contract slightly. The semistable forms have the general appearance of a hyperboloid surmounted by a saucer-shaped depression with the annular slit at the bottom. On inflating an expanded bubble by a slow stream of small air bubbles, semistable forms similar to the above are produced, but possessing an additional inflection in their contours. During these changes the maximum differences of pressure do not exceed one tenth of a millimeter of water above or below atmospheric pressure. The author shows how the apparatus can easily be modified to produce enclosing water bells. It may also be adapted to produce sonic and ultrasonic underwater vibrations.

From author's summary

1783. Nickel, K., On profiles having fixed center-of-pressure (in German), *ZAMM* **31,** 297–298, 1951.

It is shown, on the basis of thin-airfoil theory for incompressible flow, that every profile having fixed center-of-pressure must possess an inflection point in its mean-camber curve, excepting the trivial case of the uncambered profile. W. R. Sears, USA

1784. Truckenbrodt, E., Calculation of a wing profile for predetermined velocity distribution (in German), *Ing.-Arch.* **19,** 6, 365–377, 1951.

This is the latest of a series of papers by this author and by F. Riegels on approximate methods in two-dimensional thin-airfoil theory [AMR **3,** Revs. 1507, 2393; **4,** Revs. 2558, 3921]. First, the formula for induced velocity due to a source distribution is inverted to give the profile slope for a symmetrical airfoil at no incidence. Since the resulting formula involves the slope of the profile, it cannot be used directly, but can be attacked by an iteration procedure. For each step of the procedure the result is given by a summation over the prescribed velocity distribution. The coefficients are tabulated. Next, the analogous process is carried out for the camber line (skeleton) including incidence. No iteration is necessary in this case.

In combination, these two contributions represent a cambered profile with thickness and incidence. Here the refinement previously proposed by Riegels is introduced, i.e., the velocity contribution due to incidence is modified to eliminate the infinity at the leading edge. To do this, the part due to incidence, calculated for the skeleton, is multiplied by the factor $[1 + (y_t')^2]^{1/2}$, where y_t' is the slope of the (symmetrical) thickness function. The final result is a straightforward computational process for any given upper- and lower-surface velocity distributions, except for iterations needed to find the thickness function. As examples, the method is applied to several special cases, including some for which comparison with known results can be made.

W. R. Sears, USA

1785. Okabe, J., and Ohji, M., Liquid rise in a small tube, *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **7,** 1, 15–43, Sept. 1950.

Authors investigate in part I the motion, resulting from a suddenly applied pressure, in a simple manometer connected to a large reservoir through a tube of uniform diameter. Purpose of this experiment was to determine the relative importance of the terms influencing the motion. The discrepancy between the experimental and theoretical results is explained through the selection of the coefficient of friction at the wall.

In part II, constrictions of various diameter and length are inserted in the tube connecting manometer to the reservoir. The constrictions are intended to simulate various sizes of piezometer openings. Only one size manometer tube was used throughout. The motions were found to be oscillatory or nonoscillatory, according to the dimensions of the constriction.

It is shown in part I that the motion of a liquid in a simple manometer is dependent on the fourth power of the radius of the manometer. Reviewer believes, therefore, that the experiments in part II might well have included various size manometer tubes so that the results would be more generally useful.

Harlow G. Farmer, Jr., USA

1786. Byrd, P. F., Supplement to the article by N. Scholz, contributions to the lifting-surface theory (in German), *Ing.-Arch.* **19, 6,** 321–323, 1951.

The strip method of N. Scholz [AMR **4,** Rev. 286] for calculating lift and moment on a flat or circular arc profile is extended to the general case of n strips. L. M. Milne-Thomson, England

1787. Stewartson, K., On the slow motion of a sphere along the axis of a rotating fluid, *Proc. Camb. phil. Soc.* **48,** part 1, 168–177, Jan. 1952.

The slow motion of a sphere along the axis of uniformly rotating incompressible inviscid fluid is investigated. After an impulsive start at time $t = 0$, a sphere of radius a moves with uniform velocity V along the axis of rotation of the fluid having an angular velocity Ω. The quantity $V/a\Omega$ is considered small, and by the use of Laplace transform the solution is obtained in an integral form. Author investigates the behavior of the solution when Ωt is small, as well as the asymptotic behavior of the solution as $\Omega t \rightarrow \infty$. It is concluded that, in general, the motion is small and ultimately steady and two-dimensional. In agreement with experimental results, author's solution shows that a cylinder of the same diameter as the sphere is apparently pushed along in front of it.

G. V. R. Rao, USA

1788. Dean, W. R., Slow motion of viscous liquid near a half-pitot tube, *Proc. Camb. phil. Soc.* **48,** part 1, 149–167, Jan. 1952.

A complex attempt to predict the pressure signal given by a "half-Pitot tube" set flush against a wall, with simple shearing flow as the undisturbed state. The problem is idealized as a study of plane Stokes flow into the space beween an infinite plane (the "wall") and a semi-infinite plane (the outside of the "half-Pitot"), with a constant vorticity far upstream.

The solution finally chosen (involving a slight slip along the semi-infinite plate) gives an over-all pressure rise which is compared with some half-Pitot measurements of Sir Geoffrey Taylor [*Proc. roy. Soc. Lond.* (*A*) **166,** 476–481, 1938]. It shows rough agreement, though not as close as earlier crude estimates by the author [title source, **32,** 598–613, 1936] and Barker [*Proc. roy. Soc. Lond.* (*A*) **101,** 435–445, 1922]. Stanley Corrsin, USA

1789. Nevzglyadov, V. G., A new method in the dynamics of a viscous fluid (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **77,** 4, 573–576, Apr. 1951.

The flow of a viscous fluid past rigid bodies is considered as a generalization of a problem studied by Thom [*Proc. roy. Soc. Lond.* (A) **141,** 651] in the case of a circular cylinder. If the streamlines surrounding a rigid body form a tube of conveniently small cross section at infinity, then either the flow corresponds to a real flow in any interval of small Reynolds numbers, or it approaches a model which can be used in the case when the specific weight in the turbulent wake is small. A flow of this kind occurs when a fluid flows easily around a body or around a thin profile. In treating such a flow, one is not restricted to small Reynolds numbers, which is of considerable practical importance. Author gives a method for solving the dynamic problem in this field. When the stream tube, mentioned above, is conveniently chosen, the velocity $\mathbf{u}_0$ of the outer flow is found approximately by considering the case of vanishing viscosity. Supposing $\mathbf{u}_0$ known, the velocity $\mathbf{u}$ is introduced as the sum $\mathbf{u}_0 + \mathbf{v}$, the component $\mathbf{v}$ being in the mean small as compared with $\mathbf{u}_0$. Taking Navier-Stokes equations in the dimensionless form, the unknown function $\mathbf{v}(x, y, z)$ satisfies the equations

$$(\mathbf{u}_0, \nabla)\,\mathbf{v} + (\mathbf{v}\,\nabla)\,\mathbf{u}_0 = -\nabla p_1 + \frac{1}{Re}\Delta\mathbf{v}$$

$$\text{div}\,\mathbf{v} = \theta;\quad p_1 \equiv p - p_0 \qquad [1]$$

At great distances from the body $\mathbf{u}_0 \rightarrow \mathbf{u}_\infty$, and the former eqation goes over in Oseen's equation. In the region near the body, Eq. [1] is a good representation of the real flow which is convenient even in the case of greater Reynolds numbers.

The theory is developed in the simple case of two-dimensional

flow. Finally, an expression is given for the force acting in a stationary viscous flow on unit length of a cylindrical body, when the solution of Eq. [1] is known.

J. Beránek, Czechoslovakia

1790. Tomotika, S., and Aoi, T., The pressure distributions on the surface of an obstacle in a running viscous fluid at small Reynolds numbers, *Mem. Coll. Sci. Univ. Kyoto* (*A*) **26**, 9–19, 1950.

Continuing their earlier study [see AMR **4**, Rev. 767] of the exact solution of Oseen's equation for the slow flow about a sphere and a circular cylinder, the authors compute the pressure distributions about these bodies. Numerical results are presented for Reynolds numbers (based on diameter) 1 and 2 for the sphere and 0.8 and 4 for the cylinder.

J. V. Wehausen, USA

1791. Brard, R., Case of equivalence between hulls and distributions of sources and sinks (in French), *Bull. Assn. tech. marit. aéro.* no. 49, 189–220, 1950.

It is well known that the velocity field about a body in an arbitrary state of motion in a flow, steady or unsteady, may be obtained by replacing the body by a distribution of sources and sinks either on its surface or within it. Less widely known, especially for three-dimensional flows, is Lagally's theorem [*ZAMM* 2, Dec. 1922] valid for steady flows about a stationary body or for steady motion of a body through an otherwise undisturbed fluid, which asserts the dynamic equivalence between the body and the aforementioned kinematically equivalent source-sink distributions.

Present paper considers possibility of extending Lagally's theorem to cases of unsteady flows or nonuniform motions of the body. It is found that if the body is rigid and stationary in an unsteady flow, the correct resultant force on the body is obtained by adding a fictitious force to the force acting on each source. A practical extension of Lagally's theorem does not appear to be possible in the general case.

A remarkable feature of paper is the employment of measure theory in the definition of sources and source distributions and the discussion of their kinematic and dynamic properties. The treatment is limited to denumerable sets of sources and sinks so that each source or sink element may be individually followed in its motion. As a consequence of this hypothesis, the uniquely determined time-varying source distribution, which corresponds kinematically to the case of a body in arbitrary motion in an unsteady flow, may be obtained with the sources moving about the surface in an infinity of possible ways, each of which leads to a different resultant force and moment on the system. Author attempts to find a group of such source-sink motions for which the resultant force and moment would be equal to that acting on the body, but no success is achieved.

L. Landweber, USA

Compressible Flow, Gas Dynamics

(See also Revs. 1778, 1779, 1834, 1845, 1858, 1865, 1898)

1792. Foundations of high speed aerodynamics, with a bibliography by G. F. Carrier, New York, Dover Publ., Inc., 1951, 286 pp. $1.75.

Publication contains reprints of following articles (year of publication indicated in parentheses): Rankine, W., On the thermodynamic theory of waves of finite longitudinal disturbance (1870); Molenbroek, P., On certain gas flows under the assumption of a velocity potential (in German) (1890); Meyer Th., On two-dimensional flow phenomena in a gas flowing at supersonic speed (in German) (1908); Taylor, G. I., The conditions necessary for discontinuous motion in gases (1910); Lord Rayleigh, On the flow of compressible fluid past an obstacle (1916); Ackeret, J., Air forces on wings flying with a velocity greater than sound (in German) (1925); Glauert, H., The effect of compressibility on the lift of an aerofoil (1928); Prandtl, L., and Busemann, A., Approximation method for graphical determination of plane supersonic flow (in German) (1929); Busemann, A., Aerodynamic lift at supersonic speed (in German) (1935); von Kármán, T., and Moore, N. B., Resistance of slender bodies moving with supersonic velocities, with special reference to projectiles (1932); Prandtl, L., Wing theory in a compressible medium (in German) (1936); Busemann, A., Infinitesimal conical supersonic flow (in German) (1942); Emmons, H. W., and Brainerd, J. G., Temperature effects in a laminar compressible-fluid boundary layer along a flat plate (1941); Possio, C., Aerodynamic action on an oscillating airfoil in supersonic flow (in Italian) (1938); Lin, C. C., On an extension of the von Kármán-Tsien method to two-dimensional subsonic flows with circulation around closed profiles (1946); Liepmann, H. W., The interaction between boundary layer and shock waves in transonic flow (1946); Lighthill, M. J., The hodograph transformation in transonic flow. III. Flow round a body [see AMR **1**, Rev. 994]; Tomotika, S., and Tamada, K., Studies on two-dimensional transonic flows of compressible fluid. Part I [see AMR **3**, Rev. 1982].

1793. Durham, F. P., Supersonic flow with variable specific heat, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-12, 6 pp. = *J. appl. Mech.* **19**, 1, 57–62, Mar. 1952.

Equations for isentropic one-dimensional flow and for flow through plane shock waves are derived using a mean specific heat. Correction factors obtained for stagnation conditions and for the density ratio across shock waves become important when stagnation temperatures greater than about 1500 R are reached. Static-pressure ratios, however, are found to be relatively insensitive to specific-heat changes.

W. E. Moeckel, USA

1794. Ferri, A., Proper use of the M.I.T. tables for supersonic flow past inclined cones, *J. aero. Sci.* **18**, 11, p. 771, Nov 1951.

Note in Readers' Forum.

1795. Eggers, A. J., Jr., and Savin, R. C., Approximate methods for calculating the flow about nonlifting bodies of revolution at high supersonic airspeeds, *NACA TN* 2579, 40 pp., Dec. 1951.

On assumption that flow at vortex of body is conical, author derives analytical expressions for Mach numbers and pressures at the surface. In the special case of cones, the solutions define the entire flow field with good accuracy over a considerable range of free-stream Mach numbers and apex angles. When hypersonic similarity parameter is over 2, excellent results are obtained when present method is applied to ogives.

H. Reese Ivey, USA

1796. Akita, Y., Nonlinear character of the compressible aerodynamics, *Japan Sci Rev.* **1**, 2, 5–10, June 1950.

See AMR **2**, Rev. 896.

1797. Kawamura, R., On the Mach reflection of a shock wave, *J. phys. Soc. Japan* **6**, 6, 533–534, Nov.-Dec. 1951.

Author examines theoretical possibility of shocks having curvature at triple point of Mach reflection by examining pressure, flow direction, and their derivatives following shock on streamline through triple point. He concludes that curvature of reflected and Mach shock must be zero at triple point. Hence, combina-

tion of trivial solution of Mach reflection with shock curvature cannot explain experimentally observed nontrivial Mach reflection for weak incident shocks. Trivial solution is case where Mach shock is continuation of incident shock, and reflected shock is sound wave. Horton Guyford Stever, USA

1798. **Bitondo, D., Glass, I. I., and Patterson, G. N., One-dimensional theory of absorption and amplification of a plane shock wave by a gaseous layer,** *Inst. Aerophys. Univ. Toronto, UTIA Rep.* 5, 24 pp., 40 figs., June 1950.

The problem of reflection of a plane shock wave at a contact surface where two different gases are separated is treated analytically. Either a rarefaction wave or a shock wave is reflected at the discontinuity, giving, in the first case, a weakening and, in the second case, an amplification of the transmitted shock wave. Amplification coefficients for several combinations of gases are calculated. F. Schultz-Grunow, Germany

1799. **Bitondo, D., Experiments on the amplification of a plane shock wave,** *Inst. Aerophys. Univ. Toronto, UTIA Rep.* 7, 46 pp., June 1950.

Report describes experiments in which a plane shock wave is made to impinge on a contact surface separating two gases. A microfilm of solidified nitrate dope was used to separate the gases. Increases in pressure ratio across the shock waves as they passed from air into carbon dioxide or argon are compared with theoretical values calculated from the equations developed in a previous report [Bitondo, et al., see preceding review]. Experimental and theoretical results were generally in good agreement when the pressure difference across the incident shock wave was sufficiently large so that the effect of the microfilm thickness was minimized. W. E. Moeckel, USA

1800. **Mandl, P., Transition through a weak shock front,** *Inst. Aerophys. Univ. Toronto, UTIA Rep.* 14, 71 pp., 8 figs., Oct. 1951.

Author begins with a short but complete historical outline of the physical and mathematical investigations of the shock-wave problems. Then he derives the fundamental differential equation of motion, discusses its assumptions, critical points, and singularities, and shows the uniqueness of the solution. It follows the reduction to special simple cases solved by Becker and Thomas for Prandtl number 0.75. Author's new contribution is an attempt to solve the transition problem for arbitrary Prandtl numbers, assuming the coefficients of viscosity and heat conductivity as constant. The new solution is given in power series starting from the saddle point of the equation, i.e., from the final state of the transition. The numerical results are presented in tables and curves which show the transition of velocity and temperature and the change of entropy inside the shock wave. The results given for Mach number 1.05 and 1.10 and for Prandtl number 0.5 and 1 are in good agreement with the Becker solution. Increasing Prandtl number at constant Mach number decreases the length of the transition region, but the influence of the Prandtl number is only small for low Mach numbers. Karl Pohlhausen, USA

1801. **Ross, F. W., The propagation in a compressible fluid of finite oblique disturbances with energy exchange and change of state,** *J. appl. Phys.* 22, 12, 1414–1421, Dec. 1951.

Theory is presented for oblique shock waves involving (1) heat exchange k_1, (2) transfer of part of the compressible fluid k_2 to an incompressible state, (3) change in specific heat ratios k_3. It allows the study of oblique shock waves due to condensation or combustion. To establish the theory, a simple modification of classical equations is required. New shock polars are obtained, depending on 3 parameters instead of 1 (k_2 is not present). Wave-front angle varies in ordinary theory within 90° and Mach angle α; here it approaches a minimum greater than α and increases again to 90°. Flows with increase in velocity are physically possible both in subsonic and supersonic range. Stagnation pressure, too, can increase. Effects due to k_1 and k_3 are similar and additive. Applications to condensation shock in expansion around a corner and hypersonic flow are made. Gino Moretti, Argentina

1802. **Thomas, T. Y., A theory on the stability of shock waves,** Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 109–120, 1951. $10.

Paper summarizes results of author's papers reviewed in AMR **1**, Rev. 147; **2**, Revs. 80 and 1294; **3**, Rev. 318. Ed.

1803. **Gilbarg, D., The existence and limit behavior of the one-dimensional shock layer,** *Amer. J. Math.* **73**, 256–274, 1951.

Under conditions concerning the thermodynamical behavior of a viscous fluid which are shown to be equivalent to those on which the reviewer's investigation on shock layers was based [AMR **3**, Rev. 2408], author proves by an astonishingly simple discussion of signs the existence and uniqueness of a shock layer if heat conductivity λ and viscosity μ (or rather the one viscosity coefficient which matters for the one-dimensional problem) are given as arbitrary functions of the thermodynamical state. A second theorem asserts that with $\lambda \to 0$, $\mu \to 0$ the solution (if proper precaution is taken in fixing the arbitrary additive constant inhering in the coordinate x which appears as parameter) converges toward the well-known discontinuous shock wave in an ideal fluid. Also, the separate limiting processes where one of the two coefficients λ, μ tends to zero while the other is kept unaltered, are studied and shown to yield the expected results. The paper marks a decisive progress in providing a firm mathematical foundation for an important branch of the theory of the steady flow of fluids of fairly general nature.

Courtesy of Mathematical Reviews H. Weyl, Switzerland

1804. **Jonas, J., On the interaction between multiple jets and an adjacent surface,** *Aero. Engng. Rev.* **11**, 1, 21–25, Jan. 1952.

Author's aim is to determine general design criteria for cases where the above problem exists, especially concerning overheating of a surface near the wake of the jet. By theoretical and experimental investigations, author obtains some characteristic aerodynamic and geometric parameters which seem to indicate that essentially two cases have to be distinguished: (1) The surface heating increases with increasing ratio of free-stream velocity and jet velocity; and (2), the opposite behavior is true. As an application of the general analysis, tests with the F-89A fighter plane are discussed briefly. Heinrich J. Ramm, USA

1805. **Laitone, E. V., Use of the local Mach number in the Prandtl-Glauert method,** *J. aero. Sci.* **18**, 12, 842–843, Dec. 1951.

A second-order compressibility correction is obtained for utilization on thin bodies at high subsonic speeds by neglecting all higher terms than the second in the potential equation for two-dimensional isentropic flow. At low subsonic speeds it reduces to the Prandtl-Glauert correction for the surface-pressure coefficient. Robert Simon, USA

1806. **Szebehely, V. G., Local compressible pressure coefficient,** *J. aero. Sci.* **18**, 11, 772–773, Nov. 1951.

Note in Readers' Forum.

1807. Mackie, A. G., and Pack, D. C., Transonic flow past finite wedges, *Proc. Camb. phil. Soc.* **48,** part 1, 178–187, Jan. 1952.

By the method of Goldstein, Lighthill, and Craggs [AMR **3,** Rev. 931], a solution of compressible flow past finite wedges is constructed in the hodograph plane. It is shown that on the sloping edge the limiting line occurs at the sonic point. To avoid this undesirable singularity, author places the sonic point at the corner of the wedge. As the sonic line in the flow field is nonsingular, a limited supersonic flow could be obtained at subsonic free-stream Mach numbers. Author suggests, however, that the solution should terminate at the sonic line and will be joined by a local Meyer expansion at the corner. This latter problem is, however, not given. Y. H. Kuo, USA

1808. Germain, P., Researches on an equation of the mixed type. Introduction to the mathematical study of transonic flow (in French), *Rech. aéro.* no. 22, 7–20, July-Aug. 1951.

Mathematical article reviews work on boundary-value problems for Chaplygin's and Tricomi's equations, with specific reference to certain problems in transonic flow. D. C. Pack, Scotland

1809. Germain, P., Hypotheses and general methods of linearized supersonic aerodynamics (in French), *Publ. sci. tech. Min. Air, France* no. 250, 217–250, 1951.

This is a clear expository treatment of the subject. As the title indicates, author confines himself to exposition of the general methods currently in use in the linearized theory of supersonic flow, and makes no applications to particular flow problems. Appended is an extensive and carefully classified bibliography on the subject, including the applications, which should be helpful to anyone trying to find his way in the field.

Courtesy of Mathematical Reviews D. Gilbarg, USA

1810. Ivey, H. R., and Harder, K. C., A velocity-correction formula for the calculation of transonic Mach number distributions over diamond-shaped airfoils, *NACA TN* 2527, 28 pp., Nov. 1951.

By means of a simplified physical concept authors develop a formula for the Mach number distribution over a diamond-shaped airfoil which is applicable for free-stream Mach numbers ranging from high subsonic speeds to shock attachment at supersonic speed. Agreement with existing theoretical data (Vincenti, Guderley-Yoshihara, Cole) is quite good.

Gottfried Guderley, USA

1811. Krzywoblocki, M. Z. v., On the transformation of Chaplygin's equation into Fuchs-Frobenius normal form, *J. phys. Soc. Japan* **6,** 6, 452–453, Nov./Dec. 1951.

1812. Eber, G. R., Recent investigation of temperature recovery and heat transmission on cones and cylinders in axial flow in the N.O.L. aeroballistics wind tunnel, *J. aero. Sci.* **19,** 1, 1–6, 14, Jan. 1952.

Paper presents values of local temperature-recovery factor and heat-transfer coefficient for both laminar and turbulent flow determined from experiments in supersonic wind tunnel of intermittent-operation type. Laminar-flow data were obtained on cones at local Mach numbers between 0.88 and 4.63. Measured laminar recovery factor (0.845 ± .01) was independent of Mach number and Reynolds number and corresponded to theoretical value of square root of Prandtl number based on surface conditions. Laminar heat-transfer coefficients also agreed well with theory. Transitional- and turbulent-flow data were obtained along cylinder of cone-cylinder body of revolution. Turbulent recovery factors were independent of Reynolds number but dependent on Mach number (0.92 and 0.97 at 2.87 and 4.24 Mach number, respectively). Turbulent heat-transfer coefficients for case of heat flow to model were significantly lower than for case of heat flow from model, the latter agreeing with the Colburn equation for subsonic velocities.

Reviewer believes that applicability of recovery-factor data, and hence also turbulent heat-transfer data which are based on recovery-factor data, is questionable. Recent measurements obtained at other laboratories at similar Mach numbers, although at higher Reynolds number [see, e.g., forthcoming *NACA TN* by R. Scherrer and H. Stine], yield values for turbulent recovery factor considerably lower than corresponding values reported in subject paper. Dean R. Chapman, USA

1813. Johnson, J. E., and Monaghan, R. J., Measurement of heat transfer and skin friction at supersonic speeds. Preliminary results of measurements on flat plate at Mach number of 2.5, *Aero. Res. Counc. Lond. curr. Pap.* 59, 18 pp., 17 figs., Apr. 1949, published 1951.

Paper presents description of a small supersonic wind tunnel, a steam-heated flat plate, and the pressure and temperature instrumentation to be used in heat-transfer and boundary-layer research. Measurements of the turbulent recovery factor produced a value of 0.88. Heat-transfer results show that heat transfer is proportional to the difference between plate and recovery temperature and that the heat-transfer coefficient is independent of the ratio of stagnation to plate temperature for the range of conditions tested. Calculations of mean heat-transfer coefficients from measurements of the boundary-layer velocity profile were in agreement with the heat-transfer measurements.

Reviewer notes that the turbulent recovery factor of this investigation agrees with those measured at a Mach number of 2.4 on a plate by Stalder, Rubesin, and Tendeland [AMR **4,** Rev. 1703], on a cone by Wimbrow at a Mach number of 1.5 [*NACA TN* 1975, 1949], and on a cone and a cone cylinder by Stine and Scherrer at Mach numbers from 2.0 to 3.8 [*NACA TN* 2664, 1952]; however, these measurements disagree with those of Eber at Mach numbers of 2.9 and 4.2 on a cone cylinder (see preceding review). There is similar disagreement in measurements of the laminar recovery factor. The literature contains no adequate explanation of these differences. Wallace F. Davis, USA

1814. Ehlers, F. E., and Cohen, H. G., An investigation by the hodograph method of flow through a symmetrical nozzle with locally supersonic regions, *NACA TN* 2547, 61 pp., Nov. 1951.

Report deals with transonic flows in channels similar to those studied by Emmons [*NACA TN* 1003, May 1946] using relaxation methods. Analytical solutions for the flows are obtained, using the Tricomi equation as an approximation to the usual hodograph equations for perfect fluid flow. Results are qualitatively similar to those of Emmons; local supersonic regions are obtained without shocks, and several maxima and minima of the velocity along a streamline are observed. The analytic solution permits more precise study of the local velocity characteristics. Report would profit by comparison of local supersonic flows with work of Ringleb [*ZAMM* **20,** 4, 185–198, Aug. 1940] and Kraft and Dibble [*J. aero. Sci.* **11,** 4, 283–298, Oct. 1944].

David C. Prince, Jr., USA

1815. Fenain, M., Wave resistance of sweptback tapered wings with evolved profiles (in French), *Rech. aéro.* no. 24, 25–37, Nov.-Dec. 1951.

Method of homogeneous disturbances [AMR **3,** Rev. 103] in field of linearized supersonic flow theory is extended to study of

nonlifting sweptback wings with arbitrary planform taper and having symmetrical airfoil sections evolved from medium section by a prescribed transformation (generally nonaffine). Specifically,

$$x_3 = \pm \Sigma_{n=1}^{p} a_n F_n(x_1, x_2); \quad x_1, x_2 > 0$$

x_1 chordwise, x_2 spanwise directions in plane of wing, $F_n(x_1, x_2)$ homogeneous order n, defines class of surfaces considered. Author claims method involves less laborious calculation than classical procedures.

Expressions are developed for pressure field of half wings. Application is made to case of wings symmetric about Ox_1x_2 and Ox_1x_3 planes and composed of four portions of a parabolic hyperboloid (truncated triangular planform, parabolic airfoil section, hyperbolic thickness taper). Complete charts are given of drag coefficient vs. leading-edge sweepback angle for various taper ratios and ratios of leading- to trailing-edge angles (delta wings and sweptback, parallel-edged wings as limiting cases). Results indicate drag of wings of this type compare favorably with straight thickness tapered surfaces. J. S. Isenberg, USA

1816. Miles, J. W., On slender wing theory, *J. aero. Sci.* **18,** 11, 770–771, Nov. 1951.

Note in Readers' Forum.

1817. Adams, Mac C., Determination of shapes of boattail bodies of revolution for minimum wave drag, *NACA TN* 2550, 20 pp., Nov. 1951.

To determine the shapes for minimum wave drag of bodies of revolution having blunt bases, author employs von Kármán's formula for the wave drag of slender bodies, as extended to this type of body by Ward [AMR **3,** Rev. 529]. Ward and others have recently shown that von Kármán's formula is accurate to a rather high order. The optimum problem is attacked by methods of variation calculus similar to those used for bodies with pointed ends by Sears [AMR **1,** Rev. 742], Haack, Lighthill, and others. Three distinct cases are treated here; viz., bodies of given length, given basic area, and (1) given volume, (2) given maximum diameter, (3) specified diameter at a specified station. In case (3), the maximum diameter is somewhat greater than the specified one, in general; this indicates an error in the terminology of the paper by Sears cited above, where the specified diameter was called "maximum." In every case (when the base area is not zero), the optimum shape is found to have zero slope at the base. When there is base drag, i.e., when there is not a jet issuing from the base, the optimum shape will presumably be different, depending on the base pressure. W. R. Sears, USA

1818. Foote, J. R., On the uniform motion of a sphere in a nonviscous compressible fluid, Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 91–98, 1951. $10.

Paper reports an unsuccessful attempt to solve a particular boundary-value problem by an inverse method. Author "proves" that certain forms he assumes for the velocity and density functions are not consistent with the conditions to be satisfied. Unfortunately, an apparent inconsistency between two basic relations (2.1 and 2.12) casts some doubt on the proof of even this result. R. C. Prim, III, USA

1819. Nelson, H. C., and Berman, J. H., Calculations on the forces and moments for an oscillating wing-aileron combination in two-dimensional potential flow at sonic speed, *NACA TN* 2590, 36 pp., Jan. 1952.

Result originally given by Rott [AMR **4,** Rev. 788] for linearized, two-dimensional, potential flow at sonic speed over airfoil performing arbitrary small oscillations is rederived by limiting process on supersonic solution and by applying Laplace transforms. Detailed expressions are computed, using Fresnel integrals, for lift, pitching moment, and hinge moment due to wing translation, pitch and rotation of flap with zero aerodynamic balance. Results are tabulated for wide range of reduced frequencies and flap hinge locations.

Calculated forces, moments, and bending-torsion flutter speeds are compared with linearized theory for subsonic and supersonic flow. Force and moment amplitudes vary consistently with Mach number for reduced frequencies (based on wing semichord) down to about 0.1, while phase angles appear consistent down to about 0.2. Reviewer agrees with authors' statements that linearized solution leads to physically plausible results, providing the frequency is sufficiently large, and that Mach number and frequency ranges in which theory is valid await experimental or theoretical determination. Meanwhile, tabulated results used with caution should be of great practical value in flutter analysis and other applications. Holt Ashley, USA

1820. de Schwarz, Maria J., Harmonic oscillations of delta wings with supersonic leading edge (in Italian), *Aerotecnica* **31,** 5, 288–298, 306, Oct. 1951.

The wing is assumed rigid and of zero thickness. The flow potential is represented by sources on the wing following the formulas given by A. E. Puckett, P. Germain, and R. Bader.

For the case of harmonic, translational, and rotational oscillations, integral formulas are derived for the lift, moment, and local pressure coefficient. Lift and moment coefficients can be obtained without calculating the pressure distribution.

Tables of six significant digits and graphs are published, representing the real and imaginary parts of lift and moment coefficients for Mach number 1.25 and 2 for a wing with a front angle equal to the angle of the Mach cone. Reduced frequencies from 0.02 to 2.0 are covered. For the higher reduced frequencies, the formulas have been expanded into power series of the reduced frequency, including terms up to the sixth order. For two cases, lines of constant pressure are drawn on the wing planform.
Gerhard W. Braun, USA

1821. Radok, J. R. M., An approximate theory of the oscillating wing in a compressible subsonic flow for low frequencies, *Nat. LuchtLab. Amsterdam Rap.* F. 97, 1 table, 2 figs., Sept. 1951.

Paper presents approximate coefficients for the oscillating airfoil in subsonic compressible flow. Theoretical development is based on linearized theory with wake integral neglected.

Although these coefficients have been determined by exact methods, author states that the current approximations permit rapid investigation of coefficient behavior on the low-frequency range. Fair agreement exists between the approximate method and exact tabulations by Dietze. James B. Duke, USA

1822. Sauer, R., Elementary solution of the wave equation of isentropic flow (in German), *ZAMM* **31,** 11/12, 339–343, Nov./Dec. 1951.

Equation in characteristic coordinates for potential resulting, by the Legendre transformation to hodograph plane, from velocity potential for unsteady one-dimensional isentropic gas flow is established for ideal gas. This equation assumes a form studied by Darboux. Most general pressure-density relation is derived for which this properly holds. Solution then can be given in explicit form. This pressure-density relation contains 3 parameters and comprises ideal gases as special case.

Same program is followed for two-dimensional stationary flow

and gives a more complicated relation. Particular cases used by former investigators are considered. Finally, correspondence with theory of partial differential equations with straight characteristics is outlined. R. Timman, Holland

1823. Wallace, F. J., The superimposition of plane waves of finite amplitude, *Engineering* **172,** 4471, 423–425, Oct. 1951.

Equations for one-dimensional unsteady isentropic gas flow are combined into a single quasi-linear equation for velocity potential φ, such that velocity $u = \partial\varphi/\partial x$. This equation is linearized by Legendre transformations introducing variables u and $q = \partial\varphi/\partial t = -1/2\, u^2 + 5/2\,(u^2_0 - a^2)$ (a is local sound velocity). Passing over to the hodograph variables u and a, commonly used, a numerical method of superposition of waves is given using characteristics in this plane. Finally, the relation between q and the total heat of the gas is emphasized.

R. Timman, Holland

1824. Küchemann, D., A simple rule for the velocity rise with subsonic Mach number on ellipsoids of revolution, *J. aero. Sci.* **18,** 11, p. 770, Nov. 1951.

Note in Readers' Forum.

1825. Klyachkin, A. L., Polytropic gas flow (in Russian), *Zh. tekh. Fiz.* **21,** 9, 1100–1110, Sept. 1951.

It is shown that with K = const and f = const (for high values of Reynolds number), a polytropic flow of fluid is achieved for constant as well as for variable cross-sectional channels. For such flow of gases in a cylindrical tube, the thermal intensity must continually increase along the flow, reaching infinity at the limiting state. The limiting state of flow in a cylindrical tube is not related to the transition through the acoustic velocity but depends upon the law of distribution of thermal sources along the flow. Any derived velocity of the efflux, including supersonic, may be reached in a polytropic flow by one-sided and external thermal interaction. L. M. Tichvinsky, USA

1826. Kaye, J., Keenan, J. H., Klingensmith, K. K., Ketchum, G. M., and Toong, T. Y., Measurement of recovery factors and friction coefficients for supersonic flow of air in a tube. 1—Apparatus, data, and results based on a simple one-dimensional flow model, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper 51—A-29(a), 20 pp. = *J. appl. Mech.* **19,** 1, 77–96, Mar. 1952.

1827. Kaye, J., Toong, T. Y., and Shoulberg, R. H., Measurement of recovery factors and friction coefficients for supersonicflow of air in a tube. 2—Results based on a two-dimensional flow model for entrance region, Ann. Meeting ASME, Atlantic City, 1951. Paper 51—A-29(b), 10 pp.

These papers describe the experimental procedure and present the results of an investigation aimed at measuring local adiabatic wall temperatures of a supersonic stream in a round tube. A second investigation aimed at measuring local heat-transfer rates, presently under way, is not reported herein.

The range-of-diameter Reynolds number covered is from 0.15×10^5 to 5×10^5. The length Reynolds number extends to 120×10^5. The inlet Mach number is of the order of 2.5.

Authors have used the experimentally measured quantities to compute (in tabular form) quantities such as apparent friction coefficient, recovery factor, and local Mach number. These computed quantities are based upon two distinct flow models. In the initial instance (part 1), the computed quantities are based on a flow model having uniform stream properties at any cross section, and boundary-layer effects are ignored. In the second instance (part 2), the computed quantities are based upon a two-dimensional flow model in which the flow in the tube is divided into a supersonic core of variable (with length) mass with the fluid remaining in the core undergoing a reversible adiabatic change of state, and a compressible laminar boundary layer increasing in thickness in the flow direction and then undergoing a transition to turbulent boundary layer.

Authors have conducted investigations with two types of apparatus of different design in order to detect the presence of any systematic errors. No significant errors of this type were detected.

In reviewer's opinion, this work represents a marked advance into the determination and understanding of *local* phenomena in supersonic flow. The work should prove of invaluable aid to designers of apparatus utilizing or associated with supersonic flow of gases. Furthermore, the results are of great importance in the evolution of a sound theory of behavior of gases under these conditions. J. F. Manildi, USA

1828. Ribaud, G., On the establishment of the pressure level in a gas line of great length (in French), *C. R. Acad. Sci. Paris* **233,** 20, 1153–1156, Nov. 1951.

Paper treats the transient phenomena due to a compressor starting delivery at constant rate into an empty pipe line of infinite length. A solution is obtained with the aid of several simplifying assumptions resulting in expressions of static pressure and mass flow as functions of time and distance along pipe line.

Andrew Fejer, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 1781, 1873)

1829. Young, A. D., and Booth, T. B., The profile drag of yawed wings of infinite span, *Aero. Quart.* **3,** part 3, 211–229, Nov. 1951.

The boundary-layer equations and the momentum-integral equations for laminar and turbulent flow of incompressible fluid over a yawed wing of infinite span are derived first. The chordwise flow in boundary layer is independent of the spanwise flow and may be solved by any of the established methods. The spanwise flow equations are solved by assuming that flow is insensitive to the chordwise pressure distribution, and that the form of the spanwise velocity distribution is the same as that for an unyawed plate with zero external pressure gradient.

The drag coefficient of a flat plate is then calculated, which varies with yaw as $\cos^{1/2}\Lambda$ (where Λ is the angle of yaw) if the boundary layer is completely laminar, and as $\cos^{4/5}\Lambda$ if the boundary layer is completely turbulent. The drag coefficient of the NACA section so calculated varies closely as $\cos^{1/2}\Lambda$ for transition point position between 0 to 0.5 chord, with Reynolds numbers between 10^6 to 10^8, and angle of yaw up to 45°.

Experimental evidence indicates that the assumptions in this paper are reasonable. S. I. Pai, USA

1830. Meksyn, D., Numerical integration of the boundary-layer equation, *Proc. roy. Soc. Lond.* (*A*) **209,** 1098, 375–379, Nov. 1951.

Details are given of a previously sketched numerical method for solving the integrodifferential form of the Meksyn boundary-layer equation [AMR **4**, Rev. 816]. The application to Schubauer's ellipse compares satisfactorily with his measurements.

A. F. Pillow, Australia

1831. Dryden, H. L., The turbulence problem today, Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 81–90, 1951. **$10.**

This expository paper traces briefly recent developments in

understanding turbulence, and reviews knowledge gained from experimental observations as well as results obtained from theoretical statistical treatments. The scale and characteristics of phenomena which may properly be called "turbulence" are carefully discussed, and recent results and ideas concerning the origin of turbulence and the mechanism of turbulent flow (spectrum, energy transfer, etc.) are outlined. Although much progress has been made, author suggests that real understanding of the basic processes in turbulent flows may depend on the development of methods of handling the nonstationary solution of the Navier-Stokes equations. Appended are well over 100 recent references dealing with instability of laminar flows, transition, isotropic and homogeneous turbulence, spectrum of turbulence, diffusion, boundary layers, wakes, jets, flow in pipes and channels, hot-wire anemometry.

Phillip Eisenberg, USA

1832. **Inoue, E., Some remarks on the dynamical and thermal structure of a heated turbulent fluid,** *J. phys. Soc. Japan* **6,** 5, 392–396, Sept./Oct. 1951.

Two different assumptions are shown to lead to two different laws for the temperature spectrum in the intermediate eddy range; one law is a $-7/3$ power law, the other a $-5/3$ power law. To decide which assumption is valid, the laws are compared with measurements by Corrsin and Uberoi [AMR **4,** Rev. 351]. The measurements are also used in an attempt to decide whether the derived result that the effective largest eddies for the temperature and velocity fluctuations are identical is valid. It is concluded that at present no clear decisions are possible.

Neal Tetervin, USA

1833. **Krzywoblocki, M. Z. v., On the fundamentals of kinematics of statistical theories of turbulence in compressible fluids,** Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 66–80, 1951. $10.

Most of this paper is devoted to various "generalizations" of existing concepts in the theory of turbulence, which seem to consist solely of the immediate and obvious extension of these concepts to apply to temperature, density, viscosity, etc., besides velocity components and pressure with which these concepts are usually concerned. Aside from some deductions from dynamic equations and some interesting remarks about homogeneity and isotropy, the only important part of the paper seems to be the last section, which contains a few interesting and important relations between some characteristic features of turbulence in a compressible fluid.

The condition given by author for the equality of Eulerian and Lagrangian correlation coefficients on p. 74 is evidently a sufficient one, since it requires the turbulent components to be equal in both descriptions. Equality of the turbulent components being stronger than that of the correlation coefficients, the necessity of the condition given by author is by no means evident, if it can be demonstrated at all.

Chia-Shun Yih, France

1834. **Meksyn, D., Motion in the wake of a thin plate at zero incidence,** *Proc. roy. Soc. Lond.* (*A*) **207,** 1090, 370–380, July 1951.

Author applies his method of integration of boundary-layer equations [AMR **4,** Rev. 816] to title problem. He develops a successive approximation method which gives correct asymptotic behavior just aft of plate at large distances normal to plate, thus improving earlier treatments which fail as order of approximation is increased. He also considers solutions far behind plate but does not link the two. Results obtained vary from those of earlier investigators.

Morton Finston, USA

1835. **Shen, S. F., Studies of von Kármán's similarity theory and its extension to compressible flows. Investigation of turbulent boundary layer over a flat plate in compressible flow by the similarity theory,** *NACA TN* 2543, 43 pp., Nov. 1951.

Investigation of the turbulent boundary-layer flow over a flat plate in compressible flow is carried out on the basis of the scheme established in *NACA TN* 2542 [see AMR **5,** Rev. 1160]. By averaging the Navier-Stokes equations, differential equations for the mean flow are obtained. A temperature-velocity relation follows without a specified form of the length scale. To derive the velocity distribution in the boundary layer, a choice of the length scale has to be made. The temperature-velocity relation reduces to Reynolds' analogy, and the velocity distribution goes back to von Kármán's logarithmic law for the special case of incompressible flow.

There are essentially three universal constants, arising out of the correlations in the energy equation, to be determined by comparing with suitable experiments of the temperature-velocity relation at any known Mach number and heat transfer at wall. The behavior at other Mach numbers and heat-transfer conditions may then be predicted readily. Because of the lack of accurate experimental data, attempts to carry out such determinations are not included in the present report.

From author's summary by Paul Torda, USA

1836. **Rotta, J., Contribution to the calculation of turbulent boundary layer,** *David W. Taylor Mod. Basin Transl.* 242, 20 pp., Nov. 1951.

See AMR **4,** Rev. 3324.

1837. **Sato, H., Experimental study of the spectrum of isotropic turbulence. I,** *J. phys. Soc. Japan* **6,** 5, 387–392, Sept./Oct. 1951.

Some measurements were made on the turbulence behind the grid. The wind tunnel is of the single open-jet type, and the range of test section covers from 20 to 70 times of mesh length.

In the first place, the decay of total energy is proved to be inversely proportional to the distance from grid. Energy spectrum, which is observed at various positions on the center line, is nearly the same as those previously reported. The decay of spectral components was measured directly by moving the hot-wire anemometer along the axis of wind tunnel. In the low wave-number region, energy decay follows the inverse power law. But at high wave number, decay is severer at first and gradually comes to the state of energy equilibrium. The last result seems to be influenced by the free jet mixing.

From author's summary

1838. **Dhawan, S., Direct measurement of skin friction,** *NACA TN* 2567, 60 pp., Jan. 1952.

Paper describes the design and construction of a reactance-type gage capable of measuring forces from one to 100 milligrams resulting from skin friction acting on a small movable section of a flat plate. Experiments were carried out in a 4- by 10-in. continuously operating transonic wind tunnel, and the local skin-friction coefficient c_f measured at Mach numbers of 0.2 to 0.8, with a few measurements in the supersonic regime at $M = 1.37$ to 1.44. The moving element, 0.2 by 2.0 cm, is lapped flush with the flat plate and supported by a linkage system which allows it to translate in plane of the plate without rotation. Gaps at the leading and trailing edges are 0.004 and 0.008 in., respectively. Their effect on flow pattern was found to be inappreciable. The movement of the element is conveyed to the core of a Schaevitz reactance gage calibrated for known forces applied to element.

Values of c_f were measured for both laminar and turbulent

boundary layers, and close agreement with the Blasius and von Kármán theoretical curves was obtained. Paper discusses in some detail the limitations of Pitot-tube, hot-wire anemometer, and interferometer methods in skin-friction measurements, and presents several graphs showing the results obtained, the test setup, and electrical circuit employed.

Charles E. Carver, Jr., USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 1786, 1815, 1829)

1839. Hoene, H., Influence of static longitudinal stability on the behavior of airplanes in gusts, *NACA TM* 1323, 26 pp., Nov. 1951.

Translation from *ZWB Forschungsber.* no. 1422, Dec. 1940.

1840. Joy, C. F., Power-operated controls for aircraft, *Engineering* **172**, 4478, 4479; 665–666, 700–701; Nov. 1951.

Paper presents comparisons of weights, pay load, and over-all revenue for various types of electrical and mechanical power-control systems. A discussion is also included of the effects of hydraulic and electric power transmission, various control surface actuators and power sources, lag and artificial feel devices on the weight, and reliability of power-operated controls.

Arthur L. Jones, USA

1841. Owen, J. B. B., General principles of the structural design of helicopter blades, *J. Helicop. Assn.* **5**, 3, 340–351, Oct.-Nov.-Dec. 1951.

Paper deals with estimating the bending moments to which rotor blades are subject in flight. The loads tending to bend blades are analyzed, and equations for the bending equilibrium of flexible blades in the lift and drag planes are developed. The differences between loads on a rigid and a flexible blade are discussed. Author states that no great accuracy is achieved in estimating the transverse loads to which an inflexible blade is subject. Inclusion of inertia terms and omission of damping terms may give a false impression of the importance of the higher harmonic components. Damping loads on inboard region of retreating blade may be negative at particularly high speeds.

Generally, author believes high degrees of accuracy in computing fluctuating stresses is not necessary for many instances, and that "a rough estimate only of the blade stresses in forward flight is essential."

Raymond A. Young, USA

1842. Smaus, L. H., Gore, M. R., and Waugh, M. G., A comparison of predicted and experimentally determined longitudinal dynamic responses of a stabilized airplane, *NACA TN* 2578, 53 pp., Dec. 1951.

Part of the results of this paper confirms reviewer's own experience on a power-plant system study (which included air induction and exhaustion components) that a mildly stable system must be treated as unstable for practical purposes because of component tolerances or required performance.

The dynamic longitudinal stability of an airplane with autopilot was predicted by combining transfer functions of the autopilot with those of the airplane to obtain open and closed loop frequency and transient responses for the combination. The predicted responses are compared with measured data for three air speeds and several autopilot settings of displacement and displacement-rate feedback.

The linear method was used and, when the components operated in their linear range, good agreement with flight tests resulted except for some cases in which displacement-rate feedback was used. Optimum response may be estimated correctly when component performances are linear. Tolerance of nonlinearities in some of the components may be accepted.

The effect of air-speed autopilot aircraft stability may be compensated in the hinge-moment range, where the latter is roughly proportional to elevator effectiveness, by means of a simple spring mechanically linking the control surface to the servo actuator.

M. G. Scherberg, USA

1843. Marino, A. A., and Mastrocola, N., Wind-tunnel investigation of the contribution of a vertical tail to the directional stability of a fighter-type airplane, *NACA TN* 2488, 41 pp., Jan. 1952.

NACA TN 775, 1940, and *Aero. Res. Counc. Lond. Rep. Mem.* 2308, 1945, describe two widely accepted methods (in which tail area definitions differ) for predicting contribution of vertical tails to directional stability. Present author indicates these give inconsistent results within themselves, and finds additional lack of agreement with experimental results obtained on $^1/_3$-scale model of fighter with central vertical tail, and with stabilizer in three different vertical positions on fuselage. These showed that, apart from favorable end-plate effect, stabilizer had large detrimental effect on contribution of vertical tail to directional stability. This was greatest with stabilizer high and increased with increasing angle of attack. For small angles of attack, fuselage contribution was provided by that part above stabilizer; importance of this contribution increased considerably as stabilizer was lowered.

Authors conclude from tests and analysis of above methods that they cannot accurately predict contribution of vertical tail plane to directional stability for all airplane configurations and flight conditions. They suggest that, for configurations similar to type investigated, better prediction can be obtained by separate treatment of (a) vertical tail surface, (b) fuselage above stabilizer, and (c) fuselage below stabilizer.

John G. Ross, England

1844. Nowakowski, W., and Sandauer, J., Lateral stability of aircraft (in Polish), *Techn. Lotn.* **6**, 3, 58–68, Sept. 1951.

Problem discussed is important in practical engineering applications. First part of paper is a translation of Price's paper, "The lateral stability of aeroplanes," *Aircr. Engng.*, no. 173 and subsequent, 1943. Following Price, authors apply graphical analysis and restrict themselves in the second part to planes of small wing loading. On the basis of several calculated examples, they derive a few conclusions concerning lateral stability. The following items increase the lateral stability: V-type of wings, decrease of area of vertical tail surface, increase of distance between center of gravity and vertical tail surface. The first item is the most effective one. In the last part, authors discuss connection between lateral stability and behavior of a plane in a turn. In some planes (acrobatic, etc.), a small lateral instability is desirable. Rules are given which permit judging in flight whether a plane has lateral stability. This can be deduced from deflection of ailerons if the vertical tail surfaces are in neutral position, or from deflection of rudder if ailerons are in neutral position. Primarily, conclusions are valid for gliders and light planes.

Authors promise to discuss the characteristic derivatives (so important in this problem) in the next part of the paper.

M. Z. Krzywoblocki, USA

1845. Scholz, N., A method for calculating airfoils with prescribed pressure distribution, *J. aero. Sci.* **19**, 1, 70–72, Jan. 1952.

The "inverse" problem for airfoils in subsonic flow, important because of its relation to the determination of low-drag and high-critical-speed wings, is treated in a simplified manner. The

method of solution is an extension of that by Riegels [*ZWB*, 4, UM-Bericht 3019, 1943], "generalized" Joukowsky airfoils in effect being assumed as "zero"-order approximations to base profiles. Higher-order approximations are obtained with an iterative procedure using previously calculated coefficients in the trigonometric (sine) series employed to represent profile ordinates. Predictions of the second approximation and results of the early calculations of Allen [*NACA Rep.* 833, 1945] for a semi-low-drag airfoil are shown to be in good agreement, thus substantiating the accuracy of the proposed method. Application of the method to cambered airfoils at angle of attack is discussed.

Alfred J. Eggers, Jr., USA

1846. **Johns, T. F., Parachute design,** *Aero. Res. Counc. Lond. Rep. Mem.* 2402, 23 pp., 11 figs., Dec. 1946, published 1951.

Report records the methods of parachute design which were developed in this country during the latter part of World War II. It begins with a discussion of the main characteristics of a parachute and of the effects of various factors on these characteristics. It then describes the main types of parachute which are at present in use and discusses the merits of each type. Details are given of the methods of manufacture which have been found to be the most satisfactory.

It is then shown how this information is used in the design of parachutes; in particular, which shape of parachute should be used to meet specific requirements. Parachutes, it shows, may be divided broadly into two classes: Those which open at approximately their release speed, and those which slow down their load appreciably before becoming fully inflated. The design technique in the two cases is quite different, and they are therefore treated separately.

If parachutes are to be mass-produced, serious modifications have to be made to the design technique because of the variation of porosity which occurs when fabric is made in large quantities.

An indication is given of the degree of accuracy which can be expected from the methods described, and possible refinements to the design technique are suggested for use when more accurate data are available regarding the performance of parachutes. No attempt is made to deal with unconventional designs or with clusters of parachutes.

The limitations of the methods of design are discussed, and some suggestions are made for future research.

From author's summary

1847. **R.A.E. High-Speed Wind Tunnel Staff, High speed wind-tunnel tests on models of two jet-propelled fighters (Meteor and Vampire),** *Aero. Res. Counc. Lond. Rep. Mem.* 2504, 113 pp., Oct. 1945, published 1951.

Report describes measurements of lift, drag, and pitching moment made in the Royal Aircraft Establishment High-Speed Wind Tunnel on models of the Meteor and Vampire. Additional tests, including measurements of pressure distribution and tuft observations, were made to investigate alternative nacelles for the Meteor; and some further tests to investigate changes of stability and trim at high Mach numbers were made on models of both aircraft. An introduction (written in 1949) gives a general account of the tests described in the separate parts of the report.

From authors' summary

1848. **Halfman, R. L., Experimental aerodynamic derivatives of a sinusoidally oscillating airfoil in two-dimensional flow,** *NACA TN* 2465, 83 pp., Nov. 1951.

Lift and moment are experimentally determined for harmonic oscillations of an airfoil in pure pitch, pure translation, and in combined motions. These forces are measured for several amplitudes of motion and are compared with theoretical forces derived from Theodorsen's theory [*NACA TR* 496, Apr. 1935], as well as with referenced experimental data which have been reduced to the same form. Reasonable agreement is obtained for pure motions, and consistent data for pure pitching motion, as obtained by author and others, indicate several definite Reynolds-number effects. For motion corresponding to flutter, the net work per cycle is experimentally determined to be zero.

T. F. O'Brien, USA

1849. **Etkin, B., Charts for evaluating rolling performance,** *Nat. aero. Establ. Canad. Rep.* 13, 13 pp., 1951.

Three charts are presented by means of which design problems connected with rolling performance may be solved very rapidly. Typical of such problems are the following: (a) Find the aileron effectiveness $\partial C_l/\partial\xi$ required to produce a given angle of bank in a given time with a given maximum aileron angle. (b) Find the peak rate of displacement of the aileron under the same circumstances as in (a).

The maneuvers dealt with are simple rolls in which the angle of bank increases from zero to a steady value in a prescribed manner.

From author's summary

1850. **Schetzer, J. D., Notes on dynamics for aerodynamicists,** *Douglas Aircr. Co. Rep.* SM-14077, 203 pp., Nov. 1951.

Report is a clear and readable presentation of the background mathematics and theory required for the analysis of airplane control, stability, and related topics. Fundamentals of linear differential equations are considered and the various methods (Nyquist, Routh-Hurwitz, Bode's theorem) of determining the stability of systems with several degrees of freedom are demonstrated. Transient and steady-state response by classical Fourier series and transform and Laplace transform methods are developed. Applications of the basic principles are made to the study of the motion of aircraft, either with free or automatic controls; to rigid and to flexible aircraft, in which the structure deforms; and to flutter and the effects of nonsteady air forces. Particularly enlightening is the method used throughout of drawing block diagrams of complex systems in such a form that the differential equations with appropriate transfer functions can be written immediately by inspection of the block diagrams.

Herbert K. Weiss, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 1819, 1848)

1851. **Hamel, D., Theoretical determination of aerodynamic coefficients of an arbitrary structure in harmonic vibratory motion** (in French), *ONERA Note tech.* 6, 48 pp., 1951.

Given a system of aerodynamic surfaces with distributed linear elasticity and modes of vibration (outside air stream) $\varphi_i(x, y)$, it is shown to be theoretically possible to calculate coefficients of the expansion

$$A(x, y, \xi, \eta) = \Sigma\Sigma A_{ik}\varphi_i(x, y)\mu(\xi, \eta)\varphi_k(\xi, \eta)$$

(μ is mass distribution), and similarly for B, from complex, distributed, excitations $\Phi_i(x, y)$ apt to provoke, in a condition involving aerodynamic loads, oscillations corresponding with the original modes Φ_i. Here A and B are real and imaginary parts of general influence function (force at x, y due to deflection at ξ, η) representing linearized oscillatory aerodynamic loading. Functions Φ_i could be determined experimentally.

J. H. Greidanus, Holland

1852. Ghaswala, S. K., The function of aerodynamics in civil engineering, *J. Instn. Engrs. (India)* **31,** 4, 1–35, June 1951.

Author is concerned with functional importance of aerodynamics in civil engineering. Paper is divided in four sections, as follows: (1) Historical development; (2) aerodynamics of structures; (3) general problems of internal and external flow; (4) potentialities in engineering. A multitude of applications linking aerodynamics with civil engineering are dealt with. Extensive bibliography comprises important part of paper, particularly for those unfamiliar with aerodynamics and wishing to pursue the subject further. Theodore Andreopoulos, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1841, 1867, 1880)

1853. Stanitz, J. D., Some theoretical aerodynamic investigations of impellers in radial- and mixed-flow centrifugal compressors, ASME Gas Turb. Power Fall Meeting, Minneapolis, Sept. 1951. Paper 51—F-13, 25 pp. = *Trans. ASME* **74,** 4, 473–497, May 1952.

Paper presents numerical results of relaxation solutions of flow of ideal fluid through a centrifugal impeller. Theory and results are given in dimensionless form. Two types of problem are treated: (1) Axial symmetry solutions in which blade forces are replaced by distributed body forces; (2) blade-to-blade solutions giving circumferential variation of pressure and velocity between blades.

Equations for flow with axial symmetry are given for compressible fluids, but the two solutions presented are for incompressible flow through an arbitrary impeller profile with radial vanes, with and without inducer vanes. Results show that the form of streamlines in meridian section is little affected by presence of inducer vanes.

Blade-to-blade solutions are given for radial-flow impellers with constant flow area and with radial or log spiral blades, for compressible fluids in seven cases, and for incompressible fluids in one case, so that influence of change of impeller-tip Mach number, flow coefficient, angular blade spacing, blade angle and compressibility may be studied. Plots of streamlines, relative Mach numbers, and static pressure ratios allow easy qualitative comparison of different cases.

Author also presents simplified approximate methods of estimating velocity distributions along driving and trailing faces of blades and compares their accuracy with the relaxation solutions. He discusses qualitatively the influence of viscosity and boundary-layer development as affected by the frictionless flow pattern, and concludes that future centrifugal compressor development may lead to mixed-flow impellers with backward curved blades. He does not suggest, however, how the mechanical difficulties involved in producing a high-speed impeller of this type may be overcome.

The paper must be regarded as a valuable contribution to the literature on this difficult subject. Alan Burn, Australia

1854. Sheets, H. E., Nondimensional compressor performance for a range of Mach numbers and molecular weights, *Trans. ASME* **74,** 1, 93–101, Jan. 1952.

Paper describes improved method for presentation of centrifugal compressor performance using newly devised nondimensional coefficients. A flow coefficient ϕ_2, the ratio of gas velocity at impeller exit to impeller tip speed, is presented. Compressor efficiency and pressure coefficient, when plotted against ϕ_2, give single curve for all Mach numbers over range for which the usual flow coefficient based on inlet volume flow shows considerable spread. For higher Mach numbers, K_Q and K_p, dimensionless flow coefficient and pressure coefficient, respectively, are introduced; these result in a map of compressor performance that can be used for fluids of differing specific heat ratios and differing molecular weights. Reviewer believes statement in author's summary that "test data show...performance is a function of the Mach number only" is rather misleading and apparently not intended literally. E. G. Allen, USA

1855. Taylor, B. L., III, and Oppenheimer, F. L., Investigation of frequency-response characteristics of engine speed for a typical turbine-propeller engine, *NACA Rep.* 1017, 11 pp., 1951.

See AMR **4,** Rev. 2655.

Flow and Flight Test Techniques

(See also Revs. 1747, 1785, 1788, 1799, 1813, 1838, 1843)

1856. Goodman, T. R., The upwash correction for an oscillating wing in a wind tunnel, *Cornell aero. Lab. Rep.* AD-744-W-1, 19 pp., July 1951.

The upwash correction has been calculated for an oscillating three-dimensional wing in a wind tunnel at incompressible speeds. The upwash is given both at the wing itself and at downstream positions where, conceivably, a tail may be located. Three tunnel shapes have been considered: A circular tunnel, a tunnel consisting of two vertical walls, and a tunnel consisting of two horizontal walls. The tunnel upwash is calculated numerically for the entire frequency range. From author's summary

1857. Hall, N. A., Orifice and flow coefficients in pulsating flow, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-149, 13 pp.

A semi-empirical analysis of the average reading of an orifice-type flowmeter, including the case of compressible fluid. Apparently, some of the necessary empirical coefficients still await experimental determination. Stanley Corrsin, USA

1858. Bull, G. V., Starting processes in an intermittent supersonic wind tunnel, *Inst. Aerophys. Univ. Toronto, UTIA Rep.* 12, 28 pp., tables, graphs, photographs, Feb. 1951.

Paper deals, both theoretically and experimentally, with starting processes in an intermittent supersonic wind tunnel connecting two chambers of different pressure. Starting is assumed initiated by bursting of a diaphragm located between test section and low-pressure chamber.

For theoretical treatment, flow process is divided into three phases. Initial, "nonstationary" phase, beginning with bursting of diaphragm and ending with choking of nozzle throat, is analyzed by means of approximate two-dimensional theory of unsteady flow. Second, "quasi-steady" phase, which begins with choking and lasts until steady flow prevails throughout the test section, is discussed from the standpoint of conventional theory of supersonic jets. Third phase is the well-known flow which persists once steady conditions have been attained in the test section.

Experimental investigation consists of an interesting series of shadowgraphs showing time history of starting process in a 5 × 5-cm tunnel. Results verify conditions of flow postulated in theory. Experimental work also includes the case of starting diaphragm located upstream of nozzle throat. Although the initial phase of the process is completely altered by relocation of diaphragm, over-all time required to establish steady flow is changed only slightly. Paper should prove interesting to anyone concerned with operation of an intermittent tunnel.

Walter G. Vincenti, USA

1859. **Burgess, W. C., Jr., and Seashore, F. L., Criterion for condensation-free flow in supersonic tunnels,** *NACA TN* 2518, 39 pp., Dec. 1951.

Report describes an experimental investigation of water-vapor condensation in a supersonic wind tunnel at Mach numbers up to 2. The appearance of condensation shock is detected by the local increase in static pressure; the results are compared with the predictions of Volmer's theory.

The results are used to construct a chart giving the criterion for a supersonic flow to be free of water-vapor condensation, assuming that condensation occurs at a fixed theoretical value of rate of nucleus formation J. This is probably applicable in supersonic wind tunnels not greatly different in dimensions from those of the test tunnel.

Reviewer believes that the criterion for complete absence of condensation becomes much too severe at Mach numbers above about 1.6, since the required dewpoint becomes impracticably low. At higher Mach numbers, it is replaced in practice by a requirement that the amount of water-vapor condensation should not be sufficient to make appreciable change in the characteristics of the wind-tunnel test section. R. Smelt, USA

1860. **Swanson, B. S., Flow metering mechanisms and practices,** Proc. nat. Conf. indust. Hyd., 7th Meeting, **5**, 20–38, 1951.

1861. **Faro, I., Small, T. R., and Hill, F. K., The supersaturation of nitrogen in a hypersonic wind tunnel,** *J. appl. Phys.* **23**, 1, 40–43, Jan. 1952.

Tests in a small hypersonic wind tunnel have determined critical temperature and pressure conditions for the condensation of pure dry nitrogen, and indicate that, in the range of pressure (0.5–2.8 mm Hg) and temperature (52–64 R) obtained in the tests, there is a supersaturation of about 30 F.

From authors' summary

Thermodynamics

(See also Revs. 1607, 1770, 1823, 1825, 1859, 1898)

1862. **Peck, W. J., and Richmond, A. J., Applied thermodynamics problems for engineers,** London, Edward Arnold & Co., 1950, viii + 344 pp. 21s.

This book is for undergraduates, first-year graduate students, and practicing engineers who want to review or evaluate their knowledge of the fundamentals of thermodynamics. It is designed for self instruction but assumes the knowledge of a first-year course in theoretical and applied thermodynamics. It contains 169 representative fully worked examples together with explanatory matter such that an average student may follow the solutions logically. Another 139 unworked examples are given with hints, intermediate and final answers. This is not a textbook, but it is a valuable supplement to the usual engineering thermodynamics courses. W. L. Sibbitt, USA

1863. **Verschaffelt, J. E., On the thermomechanical effect** (in French), *Acad. roy. Belgique Bull. Cl. Sci.* (5) **37**, 853–872, Oct. 1951.

Author shows how problem of the thermomechanical effect can be treated in a simple manner without referring to Onsager's reciprocal relations. He examines especially the case where a molecular transformation occurs, and he indicates how the result may be applied to liquid helium II. Two appendixes are devoted to remarks on entropy production and Meixner's theorem.

From author's summary by Pierre Schwaar, Switzerland

1864. **Komatsu, K., and Nagamiya, T., Theory of the specific heat of graphite,** *J. phys. Soc. Japan* **6**, 6, 438–444, Nov.-Dec. 1951.

The graphite crystal is considered as a system of thin elastic plates spaced at a constant distance. An elastic force is assumed to act between neighboring plates in such a way that a local change of the spacing between them produces at that point a tension or a pressure normal to the plates whose magnitude is proportional to that change. The vibrations of this system are assumed to be separable into independent parts: The bending vibrations in which the displacements occur normal to the plates of the plates; and the extensional and shearing vibrations in which the displacements occur parallel to them. The frequency distributions of their normal modes are studied. The values of the elastic constants of the plates that determine the latter vibrations are derived from the force constants of the benzene molecule, while the value of the bending modulus of the plate is determined by fitting the calculated specific heat curve with the observed one. The constants of the elastic force acting between neighboring plates are derived from the measured elastic constants of graphite (mainly the compressibility). Small contributions of the electronic specific heat and the C_p-C_v correction are added to obtain the total specific heat. The result is in good agreement with experiment. From authors' summary

1865. **Korst, H. H., Analysis of some thermodynamic processes by the method of characteristics for nonsteady one-dimensional flow,** Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 320–339, 1951. $10.

The method of characteristics, here presented as it applies directly to the adiabatic isentropic case, together with supplementary procedures, permits an analysis for thermodynamic processes which are essentially based on nonsteady one-dimensional flow. Solutions for given initial and boundary conditions may be obtained, e.g., graphically, using a hodograph and a wave plane. Two examples (the pulsejet cycle and the Comprex compressor cycle) are discussed briefly. The method of iteration for the initial conditions is demonstrated in the case of the Comprex. From author's summary by Robert Sauer, Germany

1866. **Campbell, A. S., The time required for constant-volume combustion,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-15, 5 pp. = *J. appl. Mech.* **19**, 1, 72–76, Mar. 1952.

By combining the results of an elementary thermodynamic analysis of the temperature distribution in the burned gases of a constant-volume bomb with an examination of the velocity relations at the flame front, it is possible to relate the "normal burning velocity" to the time rate of production of burned gases. Integration of this equation leads to an estimate of the time required for the combustion process.

From author's summary by Walter T. Olson, USA

1867. **Pinkel, I. I., Determination of ram-jet combustion-chamber temperatures by means of total-pressure surveys,** *NACA TN* 2526, 10 pp., Dec. 1951.

A method is described by which the total temperature of the gases at the combustion-chamber outlet of a ramjet engine may be determined from the loss in total pressure measured across the combustion chamber. A working chart is presented by means of which the ratio of the total temperature of the gases at the combustion-chamber outlet to the total temperature of the gases at the combustion-chamber inlet may be determined from the measured loss of total pressure across the combustion chamber

and the known values of air flow, total pressure, and total temperature at the combustion-chamber inlet.

Values of total-temperature ratio across the combustion chamber of a 20-in. ramjet were obtained in the NACA Lewis altitude wind tunnel over a range of pressure altitude from 6000 to 15,000 ft. The difference between the temperature ratio across the combustion chamber determined from the chart and that obtained from thermocouple measurement was within 6.2% of the thermocouple-temperature ratio, and was within the accuracy of the thermocouple measurements.

From author's summary by J. Howard Childs, USA

1868. Gunn, S. V., The effects of several variables upon the ignition lag of hypergolic fuels oxidized by nitric acid, *J. Amer. Rocket Soc.* 22, 1, 33–38, Jan.-Feb. 1952.

A method is described for measuring the ignition lag of self-igniting (hypergolic) bipropellant combinations. Ignition-lag data are reported for combinations of nitric acid with aniline, furfuryl alcohol, and mixtures of aniline and furfuryl alcohol. The ignition lags ranged from about 10 to about 400 milliseconds, depending upon such variables as temperature-acid-composition, fuel composition, and metallic additives.

From author's summary

1869. Fox, J. H. P., and Lambert, J. D., The second virial coefficients of mixed organic vapours, *Proc. roy. Soc. Lond.* (*A*) **210**, 1103, 557–564, Jan. 1952.

Previous work has shown that vapors of pure substances undergo association when bond energies of dipole-dipole attraction or hydrogen bonding are larger than kT. In such a case the second virial coefficient is abnormally large and the thermal conductivity is abnormally affected by pressure. Present study shows that suitable mixtures of dissimilar compounds may also show association, even though the isolated components do not show association.

Experiments were made on *n*-hexane, diethyl ether, chloroform, and binary mixtures thereof. Only the chloroform-ether mixtures showed abnormal second virial coefficients. Relationships previously described were used to evaluate the extent of association. The bond energy of the ether-chloroform hydrogen bond was evaluated as 6020 calories per mole.

Jack D. Bush, USA

1870. Baron, T., Dynamical instability in flow systems, Proc. Midwest Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 216–225, 1951. $10.

Author studies when gases, forced through a chamber vented through a small orifice, may present dynamical instability. This never occurs when the mass-flow rates adjust themselves instantaneously to the prevailing pressure fluctuations. But if there is a time delay in adjustment, then, using equations of at least second approximation, it is shown that self-excited pressure pulsations may occur. An exact solution is given by the method of Minorsky [see *J. appl. Mech.* **9**, 2, A65–A71, June 1942]. Critical time lag for stable pulsations is also given.

Giulio Supino, Italy

1871. Taub, A. H., A sampling method for solving the equations of compressible flow in a permeable medium, Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 121–127, 1951. $10.

Paper deals with a theoretical approach to the solution of compressible flow in permeable media. Equations are developed on the basis of the Maxwell-Boltzmann distribution function of gases. Density, pressure, velocity, and heat flow are defined in accordance with kinetic theory, and a one-particle system equivalent to a many-particle system is considered. The particle is treated as undergoing a Markov process. The macroscopic quantities, density, velocity, pressure, and heat flow (as defined in the paper) satisfy the classical partial differential equations describing the flow of fluids in permeable media.

A. B. Cambel, USA

1872. Walker, R., Heat capacity lag in gases, *NACA TN* 2537, 40 pp., Nov. 1951.

A literature survey of theory and experiment on sonic studies of the problem of excitation of molecular vibrations by collision.

M. J. Goglia, USA

Heat and Mass Transfer

(See also Revs. 1813, 1916)

1873. Eckert, E. R. G., and Jackson, T. W., Analysis of turbulent free-convection boundary layer on flat plate, *NACA Rep.* 1015, 7 pp., 1951.

See AMR **4**, Rev. 2706.

1874. Plesset, M. S., and Zwick, S. A., A nonsteady heat diffusion problem with spherical symmetry, *J. appl. Phys.* 23, 1, 95–98, Jan. 1952.

As a bubble of vapor in a liquid changes size, heat flows across the interface. If spherical symmetry is assumed and appreciable temperature changes are present only in the immediate vicinity of the bubble, a solution is found in successive approximations for heat diffusion across the interface in terms of the temperature of the liquid at infinity and the temperature gradient at the spherical boundary. The effects of translational motion of the spherical boundary have not been considered and the solution is applicable to time intervals in which no significant translation occurs.

The zero-order solution obtained represents the "plane approximation" to the problem. Authors present expressions for the bounds of this solution by which the rapidity of the convergence of the approximation theory may be estimated.

William A. Wolfe, Canada

1875. Clarke, L. N., and Kingston, R. S. T., Equipment for the simultaneous determination of thermal conductivity and diffusivity of insulating materials using a variable-state method, *Austral. J. appl. Sci.* **1**, 2, 172–187, June 1950.

Temperature rise in a slab of tested material subjected to constant electric (heat) input has been measured by means of thermocouples with photoelectric feedback-galvanometer amplifier. Double symmetrical arrangement of tested sheets and steel strip heaters (mirror image by Vernotte) and side guard piles were used to eliminate the errors in boundary conditions. In appendix, four methods for calculating the conductivity and diffusivity are given. In the authors' semigraphical method, the temperature rise ($\log T_2 - \log T_1$) in double-time interval ($t_2 = 2t_1$) is plotted against functions of time and heat flux, respectively.

Otakar Maštovský, Czechoslovakia

1876. Widell, T. A., and Juhász, S. I., Metal temperature in regenerative and recuperative air preheaters, *Trans. roy. Inst. Technol. Stockholm* no. 54, 48 pp., 1952.

Air-preheater troubles are direct or indirect consequences of condensation from the flue gas on the metal surface. The difficulties have increased in recent years due to increased efficiency and to the fact that inferior fuels are being widely used.

Different methods used today to control the surface temperature of air preheaters at varying boiler loads are described.

A new method is suggested for regenerative rotary air preheaters: A combination of counterflow and parallel flow which gives the possibility of increasing the metal temperature at the cold end to the required degree, thus avoiding unnecessarily high flue-gas losses and too low hot air temperature. By this system (combiflow), the rotary air preheater is divided into three sections for the flue gas, counterflow, and parallel flow air.

Differential equations have been set up for combiflow. The solution to the homogeneous differential equation yields exponential functions.

It can be seen that all temperatures with combiflow are between the values which hold for pure counterflow and pure parallel flow. From authors' summary by S. Eskinazi, USA

1877. **Bošnjaković, F., Viličić, M., and Slipčević, B., Uniform computation of heat exchangers** (in German), *VDI-Forschungsheft* 432, 5–26, 1951.

More detailed version of an earlier publication by the senior author, including additional diagrams for the design of heat exchangers. [Compare AMR, **4**, Rev. 4618.]

H. H. Korst, USA

1878. **Rubinshteĭn, L. I., On the uniqueness of solution of the homogeneous problem of Stefan in the case of a single-phase initial condition of the heat-conducting medium** (in Russian), *Doklady Akad. Nauk SSSR (N. S.)* **79**, 1, 45–47, July 1951.

The following theorem is proved: Let $u_{1j}(x, t)$ $y_j(t)$ be two systems of solutions of the problem of Stefan:

$$\frac{\partial^2 u_{1j}}{\partial x^2} = \frac{\partial u_{1j}}{\partial t}\ (0 < x < y_j(t));\ a^2\frac{\partial^2 u_{2j}}{\partial x^2} = \frac{\partial u_{2j}}{\partial t}\ (y_1(t) < x < 1);$$

$$u_{1j}(0, t) = f_1(t) \leqq 0;\ u_{ij}(y_j(t), t) = 0;\ u_{2j}(1, t) = f_2(t) \geqq 0;$$
$$u_{ij}(x, 0) = \varphi_i(x);\ (\varphi_1(x) \leqq 0;\ \varphi_2(x) \geqq 0);$$

$$\frac{\partial y_j}{\partial t} = \frac{\partial u_{1j}}{\partial x} - \frac{\partial u_{2j}}{\partial x}\bigg|_{x=y_j(t)};\ y_j(0) = l \subset [0, 1]\ (j = 1, 2)$$

Then $t = 0$ appears as an accumulation point of the zeros of the difference $z(t) \equiv y_1(t) - y_2(t)$. The proof is based on the principle of the maximum for subparabolic functions, and from this proof it follows that there do not exist two systems of solutions of the problem of Stefan in which the boundary separating the phases are analytic functions of t.

Courtesy of Mathematical Reviews C. G. Maple, USA

1879. **Rohsenow, W. H., A method of correlating heat transfer data for surface boiling of liquids,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper 51—A-110, 12 pp., 10 figs.

An empirical formula based on bubble Reynolds number, bubble Prandtl number, and bubble Nusselt number is given to correlate the heat-transfer data for nucleate boiling of liquids for the case of pool boiling. S. I. Pai, USA

1880. **Kobayashi, A., Distribution of temperature in gas turbine rotor,** *Memo. Fac. Engng. Nagoya Univ.* **1**, **2**, 116–135, Oct. 1949.

The temperature distribution in a gas-turbine rotor, consisting of a turbine wheel connected by a shaft to a compressor wheel, is computed on the basis of several simplifying assumptions. The temperature distribution in the moving turbine blades is computed first by assuming the blades to be fins with a uniform temperature at any section perpendicular to the longitudinal axis of the blades, and second by assuming that the blade shape corresponds to a sectoral column.

The temperature distribution in the turbine disk is computed with an "equivalent heat-transfer coefficient" for a disk of uniform thickness and for a disk of arbitrary shape. The temperature in the hollow turbine shaft and in the disk of the compressor runner is also computed with the aid of equivalent heat-transfer coefficients and empirically determined coefficients. The calculated temperature distributions permit estimation of the thermal expansion, thermal stresses, cooling requirements, etc.

Joseph Kaye, USA

1881. **Codegone, C., Old and new problems in heat transfer** (in Italian), *Termotecnica* 5, 11, 481–491, Nov. 1951.

General review of the theory of heat transfer by conduction, convection, and radiation.

In conduction, author begins with the differential equation for the flow of heat in anisotropic and nonhomogeneous solids. Assuming homogeneity and no heat generation, author introduces the known principal axis transformation such that the mixed partial derivatives in the conduction equation are eliminated. After enumerating the most commonly used initial and boundary conditions, author gives some of the well-known solutions to some problems in conduction. These latter problems are treated with greater detail in "Conduction of heat in solids" by Carslaw and Jaeger.

In the short treatment of convection, the equation of state, the equation of continuity, the equation of motion, and the energy equation are discussed with little detail. Similarly, after enumerating some initial and boundary conditions pertaining to problems in convection, author gives relations of mean film coefficients for forced and free convection. A short discussion on heat convection in turbulent flow is given.

Following a summary on the general theory of radiation, the problem of incandescent cloud of coal particles is discussed. Finally, an analysis of many gray surfaces in an absorbing medium is treated with some detail.

Solutions presented in the article have a great number of typographical errors. Other references should be consulted before using equations given in this paper. S. Eskinazi, USA

1882. **Green, L., Jr., Gas cooling of a porous heat source,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper 51—A-32, 6 pp.

If a porous heated wall has a high effective surface per unit volume, one can consider the temperature of a gaseous coolant permeating the wall to be the same as that of the adjacent solid. Under this assumption, author calculates the temperature distribution and, from that, the average wall temperature, as a function of the rate of heat generation in the wall and the weight-flow-rate G of the gas (weight of the gas permeating 1 in.^{2} of the wall within a second).

Experiments by Green and Duwez have shown that the pressure-square gradient in a perfect gas in steady isothermal flow through a porous medium obeys the following formula: $-d(p^2)/dx = \alpha(2bT\mu)G + \beta(2bT/g)G^2$, where b is spec. gas constant, T abs. temperature, μ dynamic viscosity, g gravity acceleration, α, β constants of the porous medium. Instead of substituting, at each point, the proper temperature from the above calculated distribution and the corresponding value of the viscosity, and instead of integrating the flow law when considering helium flow through a graphite wall, author takes the average wall temperature and gets sufficiently accurate values for the difference between the squares of inlet and outlet pressures in terms of the weight flow rate and the heat generation. Then, for various inlet pressures, he calculates the ratio of the required pumping power to the removed thermal power, representing a figure of merit for cooling problems. At certain weight-flow rates, this ratio has a minimum, being lower the higher the inlet pressure is. The use of

high pressures is limited by the creep of the porous solid. With regard to that, graphite is a favorable material for cooling equipments. Ulrich Rost, Germany

1883. Clarke, L. N., and Kingston, R. S. T., Further investigation of some errors in a dynamic method for the determination of thermal conductivity and diffusivity of insulating materials, *Austral. J. appl. Sci.* **2**, 2, 235–242, June 1951.

Influence of cross-heat losses and thermocouple capacity in a given unstable-state method are further investigated. It is shown that the finest possible wires should be used for testing good insulators. Otakar Maštovský, Czechoslovakia

1884. Weeks, J. L., and Seifert, R. L., Note on the thermal conductivity of synthetic sapphire, *J. Amer. ceram. Soc.* **35**, 1, p. 15, Jan. 1952.

The thermal conductivity of synthetic sapphire in the direction 60 degrees from the *c* axis is shown to be 0.065 cal/sec/cm/°C at 90 to 100 C. From authors' summary

1885. Kozak, M. I., Heat conductivity of certain powders at high temperatures (in Russian), *Zh. tekh. Fiz.* **22**, 1, 73–76, Jan. 1952.

Author describes methods and results of measurement of heat conductivity of powders of quartz (silica gel) and graphite between 100 and 600 C. Heat conductivity of quartz is investigated for different sizes of grains. From author's summary

1886. Sydoriak, S. G., and Sommers, H. S., Jr., Low evaporation rate storage vessel for liquid helium, *Rev. sci. Instrum.* **22**, 12, 915–919, Dec. 1951.

By means of theoretical analysis, the problem of reducing conduction and radiant heat flux to liquid helium contained in a spherical Dewar flask is solved, thereby enabling a reduction in the evaporation loss of the helium. The modification of standard Dewar vessels as suggested by the theoretical analysis include: (1) Provisions for pumping out the vacuum jacket of the vessel to remove helium diffusing through the pyrex wall; (2) increasing the length of the Dewar portion of the neck; (3) extension of the inner wall several inches above the Dewar portion of the neck. A discussion of the operating procedure in collecting and transferring the liquid helium is given and measured loss rates are presented. Authors acknowledge the existence of a new liquid air-cooled, metallic storage Dewar, made by Superior Air Products Corp., having the same helium loss rates as their own design.

Robert J. Mindak, USA

Acoustics

(See also Revs. 1760, 1761, 1872)

1887. Kar, K. C., Datta, N. K., and Ghosh, S. K., Investigation on the bowed string with an electrically driven bow. I, *Indian J. Phys.* **25**, 9, 423–432, Sept. 1951.

Paper describes the construction of a new electrically bowed violin with very sensitive arrangements for measuring bowing pressure and velocity. Experiment is carried on to study the relation between minimum bowing pressure P_{min} to elicit a steady fundamental tone with distance d of the bowed region. Keeping the distance d fixed, the relation between minimum bowing pressure P_{min} and the bowing velocity V is studied thoroughly at two different frequencies, as well as the effect of change of the vibrating length of the string, in $P_{min} - V$ curves. A full theoretical interpretation of the curves is given for the first time.

From authors' summary

1888. Barkechli, M., Acoustic regime of a room after extinction of the source (in French), *Acustica* **1**, 2, 59–74, 1951.

Theoretical and experimental study of the reverberation phenomenon in rooms. Formulas are derived relating reverberation time with the position of a sound-absorbing patch on one of the walls of a parallelopiped-shaped room. They are of value only at low frequencies (wave length comparable with room size). At high frequencies, well-known reverberation formulas should be used. C. W. Kosten, Holland

1889. Laird, D. T., and Kendig, P. M., Attenuation of sound in water containing air bubbles, *J. acoust. Soc. Amer.* **24**, 1, 29–32, Jan. 1952.

Experiments were made to confirm high attenuations predicted by Foldy's theory for resonant air bubbles in water. Observations have a wide scatter; authors measured attenuation (on a db scale) at frequencies 2–16 kc for periods of one minute and estimated scatter and average. The greatest distance between transducer and hydrophone was 6 in. The phenomenon of resonance was well observed. Attenuation constants (db/in.) were derived for various frequencies and are uncertain by as much as 30%. The average values are in fair agreement with theory, but experimental values are not precise enough to obtain estimates of Foldy's damping constant. No consistent results were obtained in an attempt to measure the phase velocity as a function of the frequency. J. M. Jackson, Scotland

1890. Chynoweth, A. G., and Schneider, W. G., Ultrasonic propagation in binary liquid systems near their critical solution temperature, *J. chem. Phys.* **19**, 12, 1566–1569, Dec. 1951.

Measurements of the propagation of ultrasound at 600 kcps were made in a double-crystal interferometer on two binary liquid systems near critical solution temperature. Both aniline-*n*-hexane and triethylamine-water show a marked increase in sound attenuation near critical temperature. Results are qualitative but unmistakable. Authors ascribe effect to configurational relaxation associated with molecular clustering near critical temperature. Martin Greenspan, USA

1891. Tartakovskiĭ, B. D., On the passage of acoustic waves through the boundaries of rigid and fluid bodies (in Russian), *Zh. tekh. Fiz.* **21**, 10, 1194–1201, Oct. 1951.

Article gives formulas for the reflection and refraction of compression- and shear-waves at the boundary of a rigid and a fluid body. An unclear notation and some misprints detract from the article's readability. W. H. Muller, Holland

1892. Twersky, V., Multiple scattering of radiation by an arbitrary configuration of parallel cylinders, *J. acoust. Soc. Amer.* **24**, 1, 42–46, Jan. 1952.

A formal solution is developed for this problem. As the writer points out, "the derived solution, while completely general, is practically useless for purposes of calculation without the introduction of qualifying assumptions and approximations as to the character of the configuration and its components."

The researcher will find this article of value because of the generality of the solution. It should serve as an interim paper in several theoretical investigations in multiple scattering.

Keeve M. Siegel, USA

1893. Wiener, F. M., On the relation between the sound fields radiated and diffracted by plane obstacles, *J. acoust. Soc. Amer.* **23**, 6, 697–700, Nov. 1951.

The case of a planar object oscillating harmonically with uniform normal velocity is compared with the rigid fixed object

scattering a normally incident sound wave of the same frequency. It is shown that the radiated field and the mechanical radiation impedance are proportional, respectively, to the scattered field and the force per unit incident pressure. The first of these relations is admittedly self-evident; the second is useful in applying theory to practical design considerations. Diffraction data obtained by Leitner for a circular disk is used to plot the pressure distribution on the oscillating disk, directional patterns, and radiation impedance. Germane data of Stenzel, Levine and Schwinger, Molloy, and Bouwkamp (for a piston in a rigid baffle, an unflanged pipe, and an aperture in a screen of zero acoustic impedance) are presented for comparison.

Vic Twersky, USA

Ballistics, Detonics (Explosions)

(See also Rev. 1868)

1894. **Allen, W. A., Rinehart, J. S., and White, W. C., Phenomena associated with the flight of ultra-speed pellets. Part I. Ballistics,** *J. appl. Phys.* **23,** 1, 132–137, Jan. 1952.

Paper gives preliminary data from Naval Ordinance Test Station experiments with ultra-high-speed (2.5–6.0 km/sec) metallic pellets, all of $^1/_2$-in. diam, $^1/_4$-cc volume. Deceleration due to drag (up to 294,000 g) was determined from streak photographs. Authors found that deceleration of any pellet could be represented within experimental error by $-\alpha v^2$, where α is a constant which is a function primarily of material and extent of disintegration. Drag coefficients obtained agree well with reasonable extrapolation of previous data at somewhat lower Mach numbers.

Robert M. Stewart, USA

1895. **Roth-Desmeules, E., On the calculation of groups of trajectories of remote controlled rockets** (in German), *ZAMP* **2,** 6, 487–489, Nov. 1951.

Article presents a method for computing the trajectory of a beam rider, antiaircraft rocket. Author considers only the special case of the attacking aircraft flying directly over the target at constant altitude and speed. Design and performance of the rocket are taken to be known and fixed; the problems are to determine (1) the flight path, and (2) the conditions under which a successful attack can be made.

The differential equations of motion are written down, considering only principal forces. Their solution is given by a power series in the velocity and distance of the attacking aircraft at the time of launch, with the coefficients of the series being functions of time only. The coefficients are difficult to compute directly and the author recommends starting the solution by carrying out a numerical integration of the differential equations of motion for a few representative trajectories. The coefficients can then be computed from the numerical solution, and the power series will serve for interpolation.

It should be noted that the exact procedures required for actual calculations are not specified in detail nor is a numerical example given.

A. C. Charters, USA

1896. **Garnier, M., Remarkable points on a trajectory. IV. Curvilinear trajectories. Discontinuities, extrema, inflections** (in French), *Mém. Artill. fr.* **25,** 3, 693–741, 1951.

In chapter IV [for chapters I and II see AMR **4,** Rev. 4009; for chapter III, AMR **5,** Rev. 275], the special forms for following remarkable points of a curved trajectory are compiled and explained: (1) Point of discontinuity, that is, the point with the Mach number 1, where the law of resistance of Dupuis, used in the G.H.M. method, has an edge; (2) extreme values of the Mach number and points of inflection of the logarithm of this number; (3) extreme values for the velocity and for the retardation by the resistance of the air; (4) minimum of the velocity, the Mach number and the resistance in the neighborhood of the summit; (5) maximal height with respect to the curvature of the earth; (6) extreme values for the distance of the projectile from the gun.

H. Schardin, Germany

1897. **Horan, J. J., Onderdonk, J. R., and Witkin, E., Reduction of gun-gas explosion hazard in combat aircraft,** Fairchild Publ. Fund, Inst. aero. Sci. Prepr. 346, 18 pp., 15 figs., 1952.

The residual gases in the vicinity of functioning machine guns are in themselves highly explosive. When mixed in the proper proportion with air and exposed to a suitable source of ignition, these gases are capable of producing violent explosions. Such gases, present in the gun compartment of a combat-type aircraft, may result in an explosion producing considerable damage. The NADC has designed a gas-detection apparatus suitable for investigating this condition and has evolved tentative design criteria intended to aid the air-frame manufacturer and designer.

From authors' summary

1898. **Roy, M., Structure of shock waves and combustion** (in French), *C. R. Acad. Sci. Paris* **234,** 2, 168–170, Jan. 1952.

Author includes effect of change in chemical composition upon structure of a shock wave in a fluid with constant properties. For low Mach numbers, wave is approximately a constant pressure-deflagration wave, while at high Mach numbers it is a constant velocity-detonation wave. The thickness of the deflagration wave may be several hundred times that of the detonation wave. Reviewer wishes to point out results are quite qualitative due to assumption of constant coefficients of viscosity and heat conduction.

Robert E. Street, USA

1899. **Sutton, G. P., Rocket propulsion progress: A literature survey,** *J. Amer. Rocket Soc.* **22,** 1, 17–27, 31, Jan.-Feb. 1952.

Soil Mechanics, Seepage

(See also Rev. 1871)

1900. **Skempton, A. W., The bearing capacity of clays,** Build. Res. Congr., Sept. 1951, Div. 1, part 3, 180–189.

Author treats the subject of bearing capacity of saturated clays ($\phi = 0$ case) by deriving expression for bearing-capacity factors for various footing shapes and depth factors. Comparisons of bearing-capacity factors are made between values developed by theories and results of actual field observations as well as for model laboratory tests. Reasonable agreement was found in practically all cases. Approximate nature of computed factors is acceptable because practical application seldom warrants great precision. Relationship between bearing capacity and settlement is stressed, and general guides are presented to show whether bearing capacity or settlement would govern the foundation design in a given case.

Woodland G. Shockley, USA

1901. **Rowe, P. W., Anchored sheet-pile walls,** *Proc. Instn. civ. Engrs.* **1,** part I, 1, 27–70, Jan. 1952.

Descriptions are given of an important series of model tests on anchored sheet-pile walls in sand. The walls were 7 ft long and 3 ft 6 in. high. The chief variable studied was that of the flexibility of the piling. With anchor yields of more than 0.001 × height (a yield commonly exceeded in practice), no arching develops in the sand; but the bending moments in the piling are,

nevertheless, considerably smaller than those calculated on standard earth-pressure theory—the reduction in bending moment being a function primarily of the flexibility of the piling and, secondly, of the relative density of the sand. Experimental curves are given showing the relation between the reduction in movement and these variables; and the tests of Tschebotarioff lie on the curves. Author proposes a method of design consisting essentially of two steps. First, a calculation of length of piling and maximum bending moment in accordance with the well-known "free earth support" condition, and, second, a reduction of this moment depending on the flexibility of the piling and density of the sand. A discussion is included on the reasons for the reduction in moment and on the most economic designs of anchored sheet-pile walls. A. W. Skempton, England

1902. Mansur, C. I., and Perret, W. R., Efficacy of partial cutoffs for controlling underseepage beneath dams and levees constructed on pervious foundations, *Proc. Sec. int. Conf. Soil Mech. Found. Engng.* **5**, 299–311, 1948.

Paper presents a study of the efficacy of partial cutoffs below dams and levees, which do not fully penetrate the underlying permeable strata. Methods of analysis used include graphical flow nets, sand-model tests, and electrical models based on the formal similarity of Darcy's and Ohm's laws. Good correlation was obtained between these methods, and the flow nets for many special cases are given. The general conclusion is that partial cutoffs are of relatively small value in reducing either underseepage or uplift pressures. A. W. Skempton, England

1903. Habib, P., New research in soil mechanics (in French), *Ann. Inst. tech. Bât. Trav. publics* no. 224, 28 pp., Dec. 1951.

Starting from the consideration that rupture of a soil specimen occurs in a determined state, which is attained after a sequence of infinitely small changes in the material under the increase of stresses, the author has executed three tests to investigate the stress-strain relation of different soils. In triaxial tests the stress-strain curve is found to be of parabolic form until shortly before rupture. Further, it was found that the intermediate principal stress has no influence on the shearing resistance of cohesive soils, whereas in noncohesive soils this influence is important. The relation between the angle of friction and the principal stresses is given as follows (for 25 tests): For $\rho_2 = \rho_3 < \rho_1$, $\varphi = 37°$, for $\rho_3 = (\rho_1 + \rho_3)/2$, $\varphi = 57°$; for $\rho_2 = \rho_1 > \rho_3$, $\varphi = 30°$.

In tests on small-scale model piles in sand, the distribution of the friction on the shaft and the point-bearing resistance has been studied with the aid of strain gages on the shaft. The results point toward higher angles of friction for the point-bearing strata than for the layers producing the friction on the shaft, which seems to be logical because of the increased stresses in the point-bearing strata.

The third series of tests were loading tests on foundations, placed on "Shell Unedo 3" grease, which has an angle of friction of 0°. The influence of soft layers of different thicknesses on a rigid layer was studied. The movements of the grease were made visible by means of white marks, placed in the grease behind a glass panel. The results of these tests are in good agreement with the Prandtl-Caquot-Buisman formulas.

F. C. de Nie, Holland

1904. Muskat, M., The effect of withdrawal rate on the uniformity of edgewater intrusion, *J. Petr. Technol.* **3**, 12, *Petr. Trans.*, 327–330, Dec. 1951.

Paper deals with water-oil displacements in porous strata with updip. Problem is of geophysical interest, with particular reference to oil-field developments with edgewater intrusion. Author describes time-way relation of movement of the liquid-liquid interface by means of an equation, covering different characteristics of layer and liquids, such as permeability, density, and viscosity. The effect of rate of oil withdrawal on bypassing tendency, etc., under various practical conditions is discussed.

Author rightly remarks that capillary forces, although here neglected, may influence displacement process. Some further elucidation of this matter would have been welcome.

P. Wilh. Werner, Sweden

Micromeritics

1905. Taylor, Sir Geoffrey, Analysis of the swimming of microscopic organisms, *Proc. roy. Soc. Lond.* (*A*) **209**, 1099, 447–461, Nov. 1951.

The manner in which a fish swims by causing a wave of lateral displacement to travel down its body from head to tail gives rise to circulations round the body which, in a fluid of small viscosity, are necessary to produce a forward force by dynamical reaction. The propulsive organ pushes the fluid backward, while the resistance of the body gives the fluid a forward momentum. This concept cannot be transferred to problems of propulsion in microscopic bodies for which the stresses due to viscosity may be many thousands of times as great as those due to inertia.

Author studies the motion of a fluid near a sheet down which waves of lateral displacement are propagated. He calculates that the sheet moves forward at a rate $2\pi^2 b^2/\lambda^2$ times the velocity of propagation of the waves (b is the amplitude and λ the wave length). The mechanical reaction between neighboring waving tails is also studied. It has been observed that when two or more spermatozoa are close to one another, there is a strong tendency for their tails to vibrate in unison. Author analyzes the field of flow between two waving sheets when their waves are not in phase in order to find out whether the viscous stresses are of such a nature as to tend to force them into phase. Author also finds that the effort required to make the tails wave in unison was only a small part of that necessary to make them wave if out of phase (only one thousandth in the described case). It is also found that when the phase of the wave in one tail lags behind that in the other there is a strong reaction, due to viscous stress in the fluid between them, which tends to force the two wave trains into phase. L. J. Tison, Belgium

1906. Solvey-Stern, O. R., New developments in sieving analysis and modulus of fineness (in German), *Öst. Ing.-Arch.* 96, 1/2, 7–12, Jan. 1951.

1907. McNown, J. S., Particles in slow motion (English and French), *Houille blanche* **6**, 5, 701–710, 711–717, formulas, 718–722, Sept./Oct. 1951 = *State Univ. Iowa, Repr. Engng.* no. 100.

The Stokes law is restricted to solid spherical particles moving very slowly in a fluid both homogeneous and infinite in extent. The importance of the several restrictions has been studied by others, and author presents a discussion limited to some of the most significant cases. In addition to a summary of the pertinent works which have been published already, the results of new computations and experiments on the effects of certain boundary conditions (cylindrical, spherical, vertical plane, horizontal plane, two or more spheres) are presented. Author also presents results on the effects of orientation when the particles are not spherical (ellipsoidal and cylindrical particles, disks). The motion of fluid spheres is also discussed, and it seems that the most likely cause of the anomalous behavior of these fluid spheres for small

Reynolds numbers is a kind of surface rigidity resulting from contamination of the liquid interface by other substances.

L. J. Tison, Belgium

Geophysics, Meteorology, Oceanography

(See also Revs. 1694, 1774)

1908. **Bultot, F., On the curvature of discontinuity surfaces of the atmosphere** (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **37**, 11, 977–985, 1951.

Author derives a mathematical expression for the total curvature of a surface on which there is a discontinuity of a variable which is a function of space coordinates, or a discontinuity of its derivatives. The expression is applied to determine the curvature of a vertical section of a frontal surface in the atmosphere, but it would also have application in other branches of science in which the surfaces of discontinuity of space variables are significant.

J. S. Sawyer, England

1909. **Langhaar, H. L., Wind tides in inland waters,** Proc. Midwest. Conf. Fluid Dynam., 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 278–296, 1951. $10.

1910. **Takeuchi, M., Notes on the influence of motion on the temperature lapse rate and on the stability of dry and moist air,** *Pap. Meteor. Geophys.* **2**, 1, 58–64, Mar. 1951.

Concerning the influence of motion of air on the temperature lapse rate, several relations are known; for example: Margules' formula concerning vertical motion of air; Byers' formula for application to the isentropic weight chart; and Neamtan's stability tendency equation, etc.

In this paper, Margules' formula is derived in such a manner that it can be applied to motion in general, with sufficient approximation. Also, from Margules' equation, Neamtan's stability tendency equation is derived. In the case of moist adiabatic change, it is shown that a formula analogous to Margules' can be derived.

Application to the isentropic weight chart in the case of moist adiabatic change is discussed. Also some applications of Charney's equation are presented.

From author's summary by Robert O. Reid, USA

1911. **Best, A. C., Effect of turbulence and condensation on drop-size distribution in cloud,** *Quart. J. roy. meteor. Soc.* **78**, 335, 28–36, Jan. 1952.

Equations are developed to represent the rate of change of the number of drops of a given size in a cloud owing to condensation and to coalescence, respectively. Numerical computation from these equations shows that condensation has a much greater effect than coalescence on drop-size distribution in clouds with small average drop size, with small liquid-water content, or with a large degree of supersaturation. With the assumption that drop-size distribution in a cloud is governed by rate of condensation of the drops in the cloud and rate of turbulent diffusion of the drops out of the cloud, it is then shown that the fractional volume of water comprised by drops smaller than a specified size is expressible in terms of an incomplete gamma function. In this incomplete gamma function the argument is 1.5, and the upper limit to the integral varies as the square of the drop size and is also proportional to a quantity which depends upon the degree of turbulence and upon parameters connected with the rate of condensation. It is shown that this theoretical formula approximates closely to a simpler formula already established empirically, and that reasonable values for the coefficient of turbulence and the condensation parameters lead to a mean drop size which agrees closely with measured values.

From author's summary by W. C. Johnson, Jr., USA

1912. **Wagemann, H., Supplements and applications of the theory of cyclones** (in German), *Meteor. Rdsch.* **4**, 9/10, 169–172, Sept./Oct. 1951.

1913. **Wexler, A., and Brombacher, W. G., Methods of measuring humidity and testing hygrometers,** *Nat. Bur. Stands. Circ.* 512, 18 pp., Sept. 1951.

Paper reviews various methods of measuring water vapor content of the air and other gases and of creating atmospheres of given humidity in the laboratory. Instruments include psychrometers, mechanical and electric hygrometers, dewpoint indicators (manual and automatic), and other lesser-known sensing devices. Gravimetric hygrometry is also described. A list of 157 selected references is furnished, but it does not include the latest automatic dewpoint hygrometer reported [AMR **4**, Rev. 4031], nor the new edition of the Smithsonian Meteorological Tables [6th Rev. Ed., 1951] containing additional thermodynamic data applicable to the problem. It might also be noted that the Joint International Committee on Psychrometric Data is currently studying psychrometric standards. Paper constitutes valuable correlation of diversified material on moisture measurement in the atmosphere and under industrial and special conditions.

Ferguson Hall, USA

Lubrication; Bearings; Wear

(See also Rev. 1618)

1914. **Carter, D. S., An electrical method for determining journal-bearing characteristics,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51—A-27, 5 pp. = *J. app. Mech.* **19**, 1, 114–118, Mar. 1952.

Author describes the setting up of network of electrical resistances for solving the suitably substituted Reynolds equation for the pressure distribution in the oil film of a journal bearing. The basic electrical network may be constructed from constant impedance elements if the derivatives of the operator of the substitution enter only through the Laplacian form. Negative leak resistances have to be found by trial and error when the coefficient of the operator of the substitution is negative for nodes near the entering edge of the bearing. A practical example (180-deg bearing) is considered with the aid of a coarse network dividing the bearing arc into eight segments, and close agreement is obtained with Vogelpohl's result [*Ing.-Arch.* **14**, 192–212, 1943].

R. Schnurmann, England

1915. **Barwell, F. T., Research on friction and wear,** *Engineering* **172**, 4478, 4479; 649–651, 697–699; Nov. 1951.

Paper discusses work in progress on friction and wear. In most cases, final results are not yet available, but the method of attack and the different problems being considered are presented.

The first part contains a discussion of wear on the boundary conditions in bearings. It is shown that phosphating the surface of mild steel produces a film, probably porous, which decreases seizure and scuffing. It is supposed that "extreme pressure additions" to lubricants also produce protecting films, although they may increase wear.

The latter part of the paper discusses various experiments under way to determine the features of hydrodynamic lubrication in different kinds of bearings. Author, in his conclusions, indicates that perhaps more will be learned by the design aspects of bearings than of the lubricants.

Erle I. Shobert, II, USA

1916. Vogelpohl, G., Temperature distribution in lubricating film between parallel heat conducting walls (in German), *ZAMM* **31**, 11/12, 349–356, Nov./Dec. 1951.

Writer treats analytically the flow of heat in a liquid of invariant viscosity in laminar flow between a fixed and a moving surface. He assumes that at high speeds the lubricant is in contact with the walls for so short a period that the heat conducted thereto may be neglected. Results are presented as curves connecting temperature, position within film, and a parameter representing position in direction of flow divided by Péclet's number.

The temperature at the fixed wall is shown to be a maximum and that at the moving wall a minimum. Three numerical examples are presented as three-dimensional diagrams. Author concludes that the mean value of the temperature can be calculated using the mean values of the velocity of flow taken along the film, and that the flow of heat at right angles thereto may be ignored. F. T. Barwell, Scotland

1917. Brand, R. S., The hydrodynamic lubrication of sector-shaped pads, *Trans. ASME* **73,** 8, 1061–1063, Nov. 1951.

The Christopherson relaxation analysis of lubrication problems is applied to a sector-shaped pad tipped about a radial axis bisecting the sector angle. Author replaces the exact relaxation pattern by an approximate pattern which, for his problem, permits faster computation. Results presented include pressure-function contours, load coefficient, and friction-moment coefficient, all plotted against the film shape parameter.

Comparison of Norton's application of rectangular-pad results to the sector pad with the present analysis indicates that the results do not differ appreciably as far as load coefficient is concerned until large film-wedge angles are reached. If the correct mean radius is used in the friction-moment coefficient curve, Norton's results are close to those of the present analysis.
Bruno W. Augenstein, USA

Marine Engineering Problems

(See also Rev. 1791)

1918. Jasper, N. H., The TMB automatic ship's motion recorder, *David W. Taylor Mod. Basin Rep.* 777, 26 pp., Oct. 1951.

This report describes the development of an automatic ship's motion recorder which records the ship's rolling, pitching, and heaving accelerations as well as the rolling and pitching angles. The recorder has provision for automatic sampling of data at preselected intervals of time, and it can operate continuously for weeks on shipboard without requiring human attention. The apparatus may also be used to record quantities other than those mentioned; e.g., pressures and strains.

The recorder and the transducers are evaluated on the basis of their performance so far, and further worth-while developments are suggested. From author's summary

1919. Balhan, J., Measurements on some profiles used for ship propellers in two-dimensional flow with and without cavitation (in Dutch), *Ingenieur* **64,** 2, 0.1–0.7, Jan. 1952.

Measurements of chordwise pressure distribution, lift and drag on 4 bicircular sections (obtained from a circle by the Kármán-Trefftz transformation) were taken over a range of α and cavitation number σ in the cavitation tunnel of the Dutch Model Basin. Author describes measuring device. Results indicate that minimum drag-lift ratio is associated with small positive α which decreases when σ decreases. Based on these profile measurements, three propeller models have been designed for the same conditions, the one working at $\alpha = 0$ and being cavitation-free, the other two working at minimum drag-lift ratio ($\alpha = +1°$) and developing back cavitation (the difference between these two models is not stated). The efficiency of one of the two latter models proved to be 3% greater than that of the cavitation-free model.
H. W. Lerbs, USA

1920. Roach, W. H., A theoretical analysis of the dynamical stability of towed models, *David W. Taylor Mod. Basin Rep.* 796, 17 pp., Nov. 1951.

Underwater models in towing tanks are supported and towed by one or more struts. Struts have mass and compliance; therefore, system of body plus struts is subject to undesired static and dynamic deflections. Linearized equations of dynamic deflection are set up and solved to the stage of an equation for the "stability roots." Question of stability in specific case can be determined by Routh's method. No numerical examples are presented. Author suggests tests to evaluate theory. Unstable oscillations could damage expensive struts, and prior calculations might be worth-while. A. O. Williams, Jr., USA

1921. Lindblad, A. F., Further experiments with models of high speed ships, *Trans. Instn. nav. Archit.* **92, 3,** 223–234, July 1950.

Results are given of some experiments which have been carried out with a group of models of high-speed ships. The same models were used for the experiments described in the author's paper of 1948 [see AMR **3,** Rev. 1411], but they have now been tested at a beam-draught ratio of 2.75. The models have block coefficients varying from 0.535 to 0.605 and have been tested at speed-length ratios from 0.60 to 1.0.

In this paper the following questions have been the main objects of research: (1) How does the longitudinal center of buoyancy affect the resistance? (2) Which total block coefficient can economically be used? (3) How should the displacement be divided between the forebody and the afterbody, i.e., which δ_F and δ_A should be selected? From author's summary

1922. Fothergill, A. E., Vibrations in marine engineering, *Instn. Engrs. Shipb. Scot. Pap.* 1153, 50 pp., Jan. 1952 = *Trans. Instn. Engrs. Shipb. Scot.* **95,** part 4, 246–295, 1951–1952.

Author's abstract: "A survey of the vibrations, affecting main machinery and hull in practice, is followed by a historical survey of the subject. Various aspects of the problems are then discussed—hull vibration periods, torsional vibrations in the machinery, hull vibration excited by the engines, longitudinal vibration of the shafting system, and noise and vibration sensation."

Reviewer's comment: Salient features of the content of a bibliography of 40 items, including work from 1884 to the present, are placed in historical perspective.
Sanford P. Thompson, USA